

UNITED STATES SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

Form 10-K

(Mark One)

ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the fiscal year ended December 31, 2019

or

TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the transition period from to

000-31311
(Commission file number)

PDF SOLUTIONS, INC.
(Exact name of registrant as specified in its charter)

Delaware
(State or other jurisdiction of
Incorporation or organization)

25-1701361
(I.R.S. Employer
Identification No.)

2858 De La Cruz Blvd.
Santa Clara, California
(Address of Registrant's principal executive offices)

95050
(Zip Code)

(408) 280-7900
(Registrant's telephone number, including area code)

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Common Stock, \$0.00015 par value	PDFS	The Nasdaq Stock Market LLC

Securities registered pursuant to Section 12(g) of the Act:
None

Indicate by check mark if the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act.

Yes No

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act.

Yes No

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the Registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days.

Yes No

Indicate by check mark whether the registrant has submitted electronically every Interactive Data File required to be submitted pursuant to Rule 405 of Regulation S-T (§ 232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit such files).

Yes No

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company, or an emerging growth company. See the definitions of “large accelerated filer,” “accelerated filer,” “smaller reporting company,” and “emerging growth company” in Rule 12b-2 of the Exchange Act.

Large accelerated filer
 Non-accelerated filer

Accelerated filer
 Smaller reporting company
 Emerging growth company

If an emerging growth company, indicated by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act.

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Act). Yes No

The aggregate market value of the voting stock held by non-affiliates of the Registrant was approximately \$316 million as of the last business day of the Registrant’s most recently completed second fiscal quarter, based upon the closing sale price on the Nasdaq Global Market reported for such date. Shares of Common Stock held by each officer and director and by each person who owns 10% or more of the outstanding Common Stock have been excluded in that such persons may be deemed to be affiliates. This determination of affiliate status is not necessarily a conclusive determination for other purposes.

There were 32,781,567 shares of the Registrant’s Common Stock outstanding as of March 6, 2020.

DOCUMENTS INCORPORATED BY REFERENCE

Part III incorporates certain information by reference from the definitive Proxy Statement to be filed within 120 days from December 31, 2019.

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SPECIAL NOTE REGARDING FORWARD LOOKING STATEMENTS

This Annual Report on Form 10-K, particularly in Item 1 “Business” and Item 7 “Management’s Discussion and Analysis of Financial Condition and Results of Operations,” includes forward-looking statements within the meaning of Section 27A of the Securities Act of 1933, as amended (the “Securities Act”) and Section 21E of the Securities Exchange Act of 1934, as amended (the “Exchange Act”). These statements include, but are not limited to, statements concerning: expectations about the effectiveness of our business and technology strategies; expectations regarding global economic trends; expectations regarding recent and future acquisitions; current semiconductor industry trends; expectations of the success and market acceptance of our intellectual property and our solutions; the impact of the coronavirus (COVID-19) on the semiconductor industry and our business and our ability to obtain additional financing if needed. Our actual results could differ materially from those projected in the forward-looking statements as a result of a number of factors, risks and uncertainties discussed in this Form 10-K, especially those contained in Item 1A of this Form 10-K. The words “may,” “anticipate,” “plan,” “continue,” “could,” “projected,” “expect,” “believe,” “intend,” and “assume,” the negative of these terms and similar expressions are used to identify forward-looking statements. All forward-looking statements and information included herein is given as of the filing date of this Form 10-K with the Securities and Exchange Commission (“SEC”) and based on information available to us at the time of this report and future events or circumstances could differ significantly from these forward-looking statements. Unless required by law, we undertake no obligation to update publicly any such forward-looking statements.

The following information should be read in conjunction with the Consolidated Financial Statements and notes thereto included in this Annual Report on Form 10-K. All references to fiscal year apply to our fiscal year that ends on December 31. All references to “we”, “us”, “our”, “PDF”, “PDF Solutions” or “the Company” refer to PDF Solutions, Inc.

PART I

Item 1. Business

Business Overview

PDF Solutions offers products and services designed to empower engineers and data scientists across the semiconductor ecosystem to improve the yield, quality, and profitability of their products. Our products, services, and solutions include proprietary software, physical intellectual property (or IP) for integrated circuit (or IC) designs, electrical measurement hardware tools, proven methodologies, and professional services. We primarily monetize our offerings through time-based license fees, contract revenue for professional services, and increasingly recently, software as a service (or SaaS). In some cases, especially on our historical integrated yield ramp (or IYR) engagements, we also receive a value-based royalty that we call Gainshare. Our products, services, and solutions have been sold to integrated device manufacturers (or IDMs), fabless semiconductor companies, foundries, out-sourced semiconductor assembly and test (or OSATs), and system houses.

The key benefits of our offerings are improved product yields and quality, faster time-to-market, and – as a result of the prior two – increased profitability for our customers. For example, our foundry customers generate and analyze key manufacturing data using our solutions to shorten the time necessary for technology development and to provide their fabless customers with a higher yielding process with improved electrical performance, which are both critical metrics for market success. Also, for example, our IDM and fabless customers use our solutions to generate unique, differentiated data that can be analyzed with our machine learning (or ML) and artificial intelligence (or AI) algorithms to predict downstream manufacturing issues, resulting in shorter time for designs to meet performance requirements with fewer iterations and faster time-to-market. For further example, our foundry and OSAT customers use the AI and ML applications of our software to optimize for process control, assembly, and/or test.

Our long-term business strategy is to be the data analytics provider of choice for the semiconductor and electronic supply chain by enabling our customers to optimize processes, designs, and fabrication for high yield, low cost, time-to-market, and high performance. To achieve this, we intend to:

- *Develop End-To-End Analytics Offerings That Leverage Data Across The Customer Supply Chain.* As Industry 4.0 becomes the baseline standard across the semiconductor and electronics ecosystems, semiconductor companies will typically be storing tens of terabytes of manufacturing and test data, with some customers storing more than 100 TB of data. Collecting, harmonizing,

and analyzing this volume of data with traditional methods will become impractical and will require companies to look for products and solutions that minimize or eliminate data management and accelerate analytics. Our Exensio software platform provides an on-premise or cloud-based environment that includes a production-proven big data infrastructure, a common semantic data model, and advanced analytics that enables companies to leverage their historically siloed manufacturing and test data to significantly improve their operational metrics. In addition, we are now deploying ML solutions by leveraging our Exensio software platform with professional services aimed to enable our customers to push their analytics “to the edge” of their global supply chains in order to shift the analysis and decision-making processes closer to where their data is being generated. The effect of enabling edge analytics should further increase our customers’ ability to improve product yield, quality, performance, and profitability.

- *Create Differentiated Data Sources That Drive Analytics To Achieve Its Full Potential.* Historically, companies have only used data that was generated from their manufacturing and test process to drive improvements. We offer unique IP (such as Characterization Vehicle® (CV®) test chips) that is not part of an IC’s functionality, but significantly improves the manufacturing process by improving yield learning and reducing time to market. Also, our Design-for-Inspection™ (DFI™) system provides on-chip instrumentation and measurement applications from 28 nanometer (nm) down to 7nm designed to identify blockers that impact product yield and quality months earlier than any other hardware- or software-based methodology. We believe that in the More-than-Moore (MtM) era, the differentiated data we provide can play an important role in enabling our customers to bring new products to market faster and with higher quality and performance, and, ultimately, more profitability.
- *Provide High-Value, Complete Solutions For Fabless And Foundry Companies.* We are increasing the breadth and depth of our solutions that target the essential data analytics needs of our diverse customer base to meet the needs and requirements of Industry 4.0. We have developed variations of our historical products that are optimized for each type of customer – foundry, fabless, or IDM – and can be further tuned for a company’s size or development stage, from smaller, startup companies to Fortune 100 companies. These products and services can be installed on premise at the customer or in the cloud, depending on the needs of the customer for maximum flexibility and total cost of ownership (TCO). We believe this product strategy will serve us well in our established markets as well as in emerging markets such as China. Despite the current geopolitical headwinds, we feel that the long-term growth prospects are positive and we are continuing to invest sales and R&D resources for this region.

Brief History

PDF Solutions was incorporated in Pennsylvania in November 1992, and we reincorporated in California in November 1995. In July 2000, we reincorporated in Delaware, and in July 2001, we completed an initial public offering. Our shares of common stock are currently traded on the Nasdaq Global Market as PDFS. From 2000 through 2009, we expanded our technology footprint and our operations in various countries through acquisitions. From 2009 to 2019, we primarily focused on the pervasive application of our technology to leading edge logic manufacturing and achieving yield targets with our clients that maximized Gainshare royalties. In 2013, we leveraged our extensive experience in yield simulation software and CV® test chip development and started research and development on an e-beam solution for non-contact, inline electrical characterization and process control for wafer inspection. The first generation e-beam tool for DFI™ was completed in 2015, and the second generation was commercially deployed in 2019. In a parallel effort, starting in 2014, we re-architected our point-solution software tools into a new generation, highly-integrated data analytics Exensio platform, which resulted in accelerated growth in software through 2019. Headquartered in Santa Clara, California, we also operate worldwide with offices in Canada, China, France, Germany, Italy, Japan, Korea, and Taiwan.

Industry Background

Rapid technological innovation with increasingly shorter product life cycles has fueled the economic growth of the semiconductor industry since the days of the PC revolution. IC companies have historically ramped production slowly, produced at high volume once a product gained market acceptance, and slowly reduced production volume when price and demand started to decrease near the end of the product’s life cycle. Today there are many different business models across the semiconductor industry: products that follow the traditional life cycle just described, products targeted towards fast-moving market segments like Internet of Things (or IoT) – which utilize mature process nodes and requires a fast ramp to volume with a relatively short life cycle, and products focused on long term market segments like automotive and industrial where product life cycles can last a decade or longer. There is a lot of variation across these business models depending on the level of design complexity and the maturity of the process node used for product implementation. Processors, memory and field-programmable gate arrays (FPGA) continue to leverage the most advanced process nodes and experience significant challenges to achieve competitive initial yields and optimized performance. Some products and market segments, however, are content to utilize older process nodes. Regardless of the process node used for implementation or how long the product will be sold in the market, success for every semiconductor company is predicated on fast product yield ramp and the ability to optimize manufacturing and test metrics, such as yield reclamation, product quality, and test

efficiency, throughout a product's life cycle. Thus, technologies or capabilities that can accelerate yield ramp, improve product quality, and optimize production efficiencies are highly sought after because they typically lead to cost reduction and revenue generation concurrently, causing a leveraged effect on profitability.

Technology and Intellectual Property Protection

Through yield, performance, and reliability improvement services over more than 20 years, we have accumulated a vast library of physical IP in the form of test structures. As part of our DFI™ and Characterization Vehicle systems, our engineers create designs of experiments (or DOEs) and layouts for targeted fail modes. We have also developed electrical measurement hardware tools and proprietary extraction, design, and analysis software. In addition, our technology embodies many production-proven and patented algorithms. Further, our IP includes proven methodologies that our implementation teams use as guidelines to drive our customers' use of our technology. We continually enhance our core technologies through the codification of knowledge that we gain in the use of our products and delivery of services.

Our future success and competitive position rely to some extent upon our ability to protect these proprietary technologies and IP, to generate revenue from the licensed sale and support of our software and hardware to customers, and to prevent competitors from using our systems, methods, and technologies in their products or solutions. To accomplish this, we rely primarily on a combination of contractual provisions, confidentiality procedures, trade secrets, and patent, copyright, mask work, and trademark laws. We license our products and technologies pursuant to non-exclusive license agreements that impose restrictions on customers' use. In addition, we seek to avoid disclosure of our trade secrets, including requiring employees, customers, and others with access to our proprietary information to execute confidentiality agreements with us, and restricting access to our source code. We also seek to protect our software, documentation, and other written materials under trade secret and copyright laws. We seek to protect our IP under patent laws and as of December 31, 2019, we held 160 U.S. patents. Our issued patents have expiration dates from 2020 through 2038. We intend to prepare additional patent applications when we feel it is beneficial. We also employ protection of our trademarks, with registration of marks, including Characterization Vehicle, CV, eProbe, Exensio, pdFasTest, PDF Solutions, the PDF Solutions logo. We have common law rights to additional trademarks, including ALPS, DFI DirectProbe, and DirectScan.

Products and Services

Products

Our software is typically sold with maintenance and support and other related services, which are described below, or provided as a service (known as "SaaS"), or combined with our proprietary hardware products to form systems that we then further combine with services, as described below. Our primary products and systems include the following:

Exensio Software Products. Our separately-offered Exensio software products address the big data manufacturing challenge of today's advanced process nodes and highly integrated products, by enabling links across fab, test floor, and other enterprise data types. These data types include inline and end-of-line metrology, yield, parametric, performance, manufacturing consumables, tool-level sensor data, test floor data, logistical data, as well as custom data types. By providing a common environment for all these different data types from many different points in the manufacturing and test process, our Exensio products are designed to enable customers to rapidly perform root cause diagnosis of yield, performance, and quality issues that impact manufacturing and test operations. These products are also designed to enable predictive and proactive optimization decisions for process control, process adjustments, PM scheduling, tool corrective actions, wafer dispatching, and wafer level and final test. Collectively, our Exensio products are designed to enable real-time rapid diagnosis and understanding of key manufacturing and test metrics during both inline and end-of-line wafer processing, helping customers reduce product variability and cost simultaneously. Our Exensio products also address the problem of silos of data which without our software only allows local optimization. By integrating these silos of data and applying AI and ML, our Exensio products are designed to provide foresight across the entire production process, reducing the time it takes to make critical decisions that can drive higher product yield, quality and reliability. Exensio products are available as either an on-premise license or SaaS. There are four main, separately-offered Exensio products and many optional modules to provide specific capabilities to address a particular type of company's needs and requirements, including primarily, as follows:

- *Exensio Yield* – This software collects yield data and stores it in an embedded, analysis-ready database, providing a common environment and a consistent view of all product yield data, and is designed to enable product engineers to identify and analyze production yield, performance, reliability and other issues. Elements of this product are designed to handle very large data sets that are commonplace in the semiconductor industry and, in combination with other Exensio analytic modules, aid engineers in diagnosing complex issues that negatively impact productivity, yield, and time-to-market for the products they develop. To support the multi-dimensional product requirements of our customers, the powerful, interactive visualization and analysis capabilities in this product are highly flexible and user-configurable.

- *Exensio Control* – This software provides failure detection and classification (or FDC) capabilities for monitoring, alarming and control of manufacturing tool sets. These capabilities include proprietary data collection and analysis of tool sensor trace data and summary indicators designed to rapidly identify sources of process variations and manufacturing excursions. When used together with Exensio Yield and related modules, the accretive data mining and correlation capabilities are designed to enable identification of tool level sources of yield loss and process variation that impact end of line product yield, performance and reliability.
- *Exensio Test* – This software provides comprehensive data collection and analysis capabilities for data generated during manufacturing test operations designed to optimize test operations management overall, including improving test productivity, performing part average test, supporting test floor operations, and implementing adaptive test. Exensio Test is also designed to provide predictive insights based on proprietary analytics during test, assembly and packaging to maximize the efficiency of test operations, productivity improvements and yield reclamation.
- *Exensio ALPS* – This software provides device manufacturers with the capability to link assembly and packaging data with other product lifecycle data, including fabrication and characterization data, across the product life cycle. Data sources could include manufacturing, wafer acceptance test, wafer sort, test and assembly, final test, and field use. The proprietary data linkage enabled by Exensio ALPS is also designed to enable device manufacturers to maintain full traceability of their finished products back to the source wafer without the need for Electronic Chip IDs (or ECIDs). This capability is becoming an essential requirement for safety-critical market segments such as automotive and military-aerospace.

Design-for-Inspection (or DFI) System. Our DFI System is a combination of on-chip measurement instruments, hardware to measure such instruments, software to insert the instruments into customer layouts and analyze the results, and related services. This system is designed to enable our customers to achieve non-contact, inline electrical characterization and more effective process control. The DFI system provides customers an ability to insert on-chip instruments with calibrated electrical responses directly in the product wafer without die area penalty. In addition, the DFI system is designed to be high-throughput, enabling inline use. The electrical measurements augment and enhance existing inline defect inspection and metrology methods. The DFI system leverages our production-proven design and analysis infrastructure. The primary software and hardware products included in the DFI system are as follows:

- *DFI™ On-Chip Instruments* – Our on-chip measurement instruments are developed using our proprietary FIRE™ layout analysis software and are tuned to capture key features of our customers' product layouts. As part of the system offering, we generally provide design services to create these instruments. These DFI instruments designed to be placed in test chips, scribe lines, or in product die, without any area penalty, and to exhibit specific electrical responses.
- *eProbe® Non-Contact E-Beam Tool* – Our eProbe e-beam tools are designed to measure the electrical response of the DFI instruments. This unique, differentiated data is a measure, which we call an Electrical Response Index (or ERI), that is designed to allow for more precise inline characterization of design-process interactions. As part of the system offering, we generally provide tool support services to customers to operate this tool. The second generation tool includes orders of magnitude advances in throughput and accuracy that now enable DFI on-chip instruments to be used for inline control for leading-edge semiconductor process nodes.
- *Exensio Characterization Software*– This software, which is also a part of our Exensio platform, is designed to analyze the billions of measurements collected from DFI on-chip instruments using the eProbe tool. As part of the system offering, we generally provide analysis services to customers to perform this analysis and provide summary findings and recommendations.

There are two configurations for the DFI System:

- *Foundry Configuration* – We provide foundry customers with a complete DFI system for inline characterization and process control. This DFI infrastructure includes not only on-wafer IP, or on-chip instruments, but also the eProbe measurement tool and the Exensio Characterization software for DFI data processing and analysis. All aspects of the foundry offering are designed to be optimized for high data contrast, fast data handling, and comprehensive data analysis to provide foresight into downstream issues that could impact yield, reliability, or performance.
- *Fabless Configuration* – We work closely with our fabless customers to tune the DFI on-chip instruments to reflect the key aspects of their product designs. As part of this configuration, we generally provide our DFI insertion software kit to customers, which is designed to efficiently distribute DFI filler cells across the die, for maximum issue coverage with fast readout. The DFI system is designed to enable fabless companies designing products at 28 nanometers and below to achieve better manufacturing results.

Characterization Vehicle (CV) System. Our CV System is a combination of CV test chips, hardware to test such products, software to analyze the test results, and related services. This system is designed to accelerate the efficiency of yield learning by shortening the learning cycle, learning more per cycle, and reducing the number of silicon wafers required in manufacturing processes. This system includes physical IP in the form of test structures and DOEs that are tuned to our customers' product and/or process specifics, tester hardware, data analysis, and training. The primary software and hardware products included in the CV system are as follows:

- *CV Test Chips* – Our proprietary test chips are designed by our professional engineers using our proprietary FIRE™ layout analysis software. These test chips are run through a customer's manufacturing process, with intentional process modifications, to provide unique, differentiated data to explore the effects of potential process improvements given natural manufacturing variations. Our custom-designed CV test chips are optimized for our test hardware and analysis software and include DOEs tuned to each customer's process. Types of CV test chips include:
 - Our full-reticle and shared-reticle CV test chips are designed to provide a fast learning cycle and are fully integrated with third-party failure analysis and inspection tools for a complete diagnosis to understand root causes. Our full-reticle CV test chips use a shortened process flow to provide a faster learning cycle for specific process modules.
 - Our Scribe CV test chip are inserted directly on customers' product wafers to collect data about critical layers.
 - Our DirectProbe™ CV test chips are designed to enable ultra-fast yield learning for new product designs by allowing our clients to measure components of actual product layout.
- *pdFasTest® Electrical Tester* – Our proprietary test hardware is optimized to quickly test our CV test chips, enabling fast defect and parametric characterization of manufacturing processes. As part of the system offering, we provide test programs for each CV test chip that are tuned to the customer's process. This automated system provides parallel functional testing, thus minimizing the time required to perform millions of electrical measurements to test our CV test chips. We provide services to analyze the unique, differentiated data output of this tester using the Exensio Characterization software to provide actionable insights to our customers.
- *Exensio Characterization software* – This software, which is also a part of our Exensio platform, collects the data generated from our CV test products, generating models of the performance effects of process variations on these design building blocks. As part of the system offering, we also offer analysis services, if the customer elects not to do such analysis itself.

Services

Our services are virtually always sold together with, or to support, our products and systems and include the following:

Software-as-a-Service (SaaS) – We provide services to make our Exensio software available to our customers via the Internet, generally hosted by third-party providers. SaaS is considered part of cloud computing since the software is hosted on the Internet, or the "cloud." Since our SaaS applications are accessed from a remote server rather than installed on individual machines, it is easier to maintain. For example, when the remote software is updated, the customer's interface is also updated for all users. Cloud computing is designed to eliminate incompatibilities between different software versions and allow us to make incremental updates without requiring software downloads. Additionally, our customers can save data to a central online location, which is designed to allow increased project collaboration.

Software Related Services – We provide software maintenance and support (or M&S), data management services, various value-added services (or VAS) to install, configure, or create analysis templates, and other professional services to achieve customers' specific outcomes using our software. We call this last type of services our AIM solutions and, in these cases, we tailor the user flows of one or more Exensio products to achieve a desired result. For example, our AIM YieldAware™ FDC offering is designed to identify the process control variables that have the greatest impact on product yield through professional services that analyze the data from both Exensio Control and elements of Exensio Yield and make recommendations for the customer to implement. VAS are provided by our professional service personnel with expertise that enhances and complements the engineering teams at our customers. For example, VAS includes our data cleaning and monitoring services. One requirement of big data analytics is to have clean, harmonized data to analyze. This service offering outsources the data wrangling and management effort to free the customer to focus their efforts on analysis, which has a greater ROI to the company than data management.

IYR Services – These services are designed to characterize key product and/or process elements, primarily into CV test structures or DFI on-chip measurement instruments, and typically include performance incentives based on the customers’ yield achievement. We provide these services, together with all of the elements of our CV system, to foundry customers as an Integrated Yield Ramp project in connection with new process technology development and yield ramp. In IYR engagements, we generally provide the analysis of our CV test chips and provide summary findings and recommendations to the customer. IYR engagements can include DFI systems for use during the implementation period. As electrical scaling has slowed down significantly over the past few years, we have chosen to focus our resources and investment in analytics, however, these IYR services are still offered from time to time.

Customers

Our existing customers include foundries, IDMs, fabless semiconductor design companies, OSATs, as well as some equipment manufacturers, including those that embed and distribute our Exensio ALPS products in their equipment. Our semiconductor customers’ targeted product segments vary significantly, including microprocessors, memory, graphics, image sensor solutions, and communications. We believe that the adoption of our solutions by such companies for usage in a wide range of products validates the application of our solutions to the broader semiconductor market. We often have multiple contracts with a single customer or customer group, with no interdependent performance obligations. In general, our customer contracts are non-cancellable.

GLOBALFOUNDRIES Inc., which, together with its subsidiaries, we collectively call GlobalFoundries, represented 31% of our revenues for 2019 and 37% of our revenues for 2018. No other customer accounted for 10% or more of our revenues in 2019 and 2018. See the discussion in “Risk Factors” under Item 1A for more information about risks associated with customer concentration and contractual provisions.

International revenues accounted for approximately 58% of our total revenues for 2019 compared to 60% for 2018. We base these calculations on the geographic location of where the work is performed or where the customer is located. Revenues from customers by geographic area based on the location of the customers’ work sites for our last two fiscal years can be found in Note 13, “Customer and Geographic Information” to the consolidated financial statements. Additional discussion regarding the risks associated with international operations can be found under Item 1A, “Risk Factors”.

See our “Notes to Consolidated Financial Statements”, included under Part II, Item 8. “Financial Statements and Supplementary Data” for additional geographic information.

Sales and Marketing

Our sales strategy is to pursue targeted accounts through a combination of our direct sales force, our service teams, and strategic alliances. After we are engaged by a customer and early in the services process, our engineers seek to establish relationships in the organization and gain an understanding of our customers’ business issues. Our direct sales and service teams combine their efforts to deepen our customer relationships by expanding our penetration across customers’ products, processes, and technologies. This close working relationship with each customer has the added benefit of helping us to identify new product areas and technologies in which we should next focus our research and development efforts. From time-to-time, we use sales representatives/agents in various locations to augment direct sales in certain territories. We expect to continue to establish strategic alliances with process licensors, vendors in the electronic design automation software, capital equipment for IC production, and test silicon IP and mask-making software segments to create and take advantage of sales channel and co-marketing opportunities. Additionally, we expect to form relationships with key value chain participants, including foundries and OSATs, to provide services and value across the manufacturing supply chain.

Research and Development

Our research and development focuses on developing and introducing new proprietary technologies, including our Exensio platform and DFI and CV systems, as well as other software products and enhancements to our existing solutions, such as field applications for DFI and CV. We use a rapid-prototyping paradigm in the context of the customer engagement to achieve these goals. We have made, and expect to continue to make, substantial investments in research and development. The complexity of our technologies requires expertise in physical IC design and layout, transistor design and semiconductor physics, semiconductor process integration, numerical algorithms, e-beam technology, hardware, statistics and software development. We believe that our team of engineers will continue to advance our market and technological leadership. We conduct in-house training for our engineers in certain technical areas. Our training also extends to focusing on ways to enhance client service skills. Although it fluctuates, we can have up to one quarter of our research and development engineers operating in the field, partnered with solution services engineers, in a deliberate strategy to provide direct feedback between technology development and customer needs. We also utilize a variety of skilled independent contractors for specialized development.

Competition

The semiconductor industry is highly competitive and driven by rapidly changing design and process technologies, evolving standards, short product life cycles, and decreasing prices. We expect market competition to continue to develop and increase as the market for data and analytics continues to evolve. We believe IC companies benefit from a combination of big data management infrastructure, AI/ML-based analytics engines, and products that generate and collect differentiated data that enrich the analytics process. Currently, we are a leading provider of comprehensive commercial hardware, software and IP solutions for optimizing and improving design, manufacturing and test operations processes through the application of differentiated data and advanced analytics. We face indirect competition from internal groups at IC companies that offer tools with varying degrees of optimization to accelerate process-design integration or test operations. Some providers of semiconductor manufacturing software, inspection equipment, electronic design automation, or design IP may seek to broaden their product offerings and compete with us. In each of the market segments we compete in, we face competition from established and potential competitors, some of whom may have greater financial, research, engineering, manufacturing and marketing resources than we have.

We face competition for some of the point applications of our products, including some of those used by the internal groups at IC companies. Specifically there are several suppliers of (i) yield management and/or prediction systems, such as KLA-Tencor, Siemens AG (Siemens), Rudolph Technologies, Inc. (Rudolph), Synopsys, Inc., and Qualtera, (ii) semiconductor manufacturing software, such as Applied Materials, Inc. (Applied Materials), BISTel Inc., Invantest, Inc., Optimal+, Rudolph, and Siemens and, (iii) inline inspection, metrology and electrical test equipment providers, such as Applied Materials and Keysight Technologies, Inc. Further, we may compete with the products or offerings of the same or additional companies if we expand our offerings, or they expand their offerings, through acquisition or development.

We believe that our solutions compare favorably with respect to competition because we have demonstrated results and reputation, strong core technology, ability to create innovative technology, and ability to implement solutions for new technology and product generations. See the discussions in “Risk Factors” under Item 1A for more information about risks associated with our competition.

Employees

As of December 31, 2019, we had 353 employees worldwide, including 196 on client service teams, 100 in research and development, 23 in sales and marketing, and 34 in general and administrative functions. Of these employees, 157 are located in the United States and Canada, 161 in Asia, and 35 in Europe.

None of our employees are represented by a labor union. Our employees in France and Italy are subject to collective bargaining agreements in those countries. We believe our relationship with our employees is good. Competition is intense in the recruiting of personnel in our industry. We believe that our future success will depend, in part, on our continued ability to hire and retain qualified management, marketing and technical employees.

Information about our Executive Officers

The following table and notes set forth information about our current executive officers as of the date of this Form 10-K.

Name	Age	Position
John K. Kibarian, Ph.D.	55	President, Chief Executive Officer, and Director
Christine A. Russell	70	Executive Vice President, Finance and Chief Financial Officer (through March 10, 2020)
Adnan Raza	46	Executive Vice President, Finance and Chief Financial Officer (beginning March 11, 2020)
Kimon Michaels, Ph.D.	53	Executive Vice President, Products and Solutions

John K. Kibarian, Ph.D., one of our founders, has served as President since November 1991 and has served as our Chief Executive Officer since July 2000. Dr. Kibarian has served as a director since December 1992. Dr. Kibarian received a B.S. in Electrical Engineering, an M.S. E.C.E. and a Ph.D. E.C.E. from Carnegie Mellon University.

Christine A. Russell, joined in July 2018 as Vice President, Finance, and was appointed Chief Financial Officer effective August 10, 2018 and ceased to be the Chief Financial Officer as of the filing of this Form 10-K. Ms. Russell was designated as an Executive VP in February 2019. Prior to joining the Company, Ms. Russell served as Chief Financial Officer, UniPixel, Inc. (Nasdaq:UNXL), a touch sensor company, from May 2015 to August 2017. Prior to UniPixel, she was Chief Financial Officer of Vendavo, Inc. from May 2014 to March 2015, a SaaS based pricing and margin optimization software company. She also served as Chief Financial Officer of Evans Analytical Group (EAG) from May 2009 to September 2013, a global provider of analytical testing for technology companies including major semiconductor, chemicals and pharmaceuticals firms. Prior to EAG, she served in the roles of both Chief Financial Officer and EVP Business Development at Virage Logic (Nasdaq:VIRL), a semiconductor intellectual property company. Prior positions include Chief Financial Officer for OuterBay Technologies, a database archiving software company and Chief Financial Officer of Ceva, Inc. (Nasdaq: CEVA), a DSP IP company. She currently serves as Audit Committee Chair and Director for both QuickLogic Corporation and eGain Corporation, and as Audit Committee Member and Director for AXT, Inc. Ms. Russell holds a B.A. and M.B.A. from the University of Santa Clara.

Adnan Raza, joined in January 2020 as Executive Vice President, Finance, and was appointed Chief Financial Officer effective as of the filing of this Form 10-K. Prior to joining the Company, Mr. Raza served as an independent strategy consultant for private and public companies from July 2019 to January 2020. Prior to that, Mr. Raza served in various roles at Synaptics Inc., a developer of human interface technologies, including as Senior Vice President of Corporate Development from August 2017 to June 2019 and Vice President of Corporate Development from February 2015 to August 2017. Prior roles include technology investment banking at Goldman, Sachs & Co. and UBS Investment Bank, strategic advising at Blackreef Capital, engineering and marketing at Azanda Network Devices, and engineering at Lucent Technologies. Mr. Raza also served as a Board Member at FIDO Alliance, an alliance of leading technology companies to enhance user security and authentication. Mr. Raza holds a Master of Business Administration (MBA) from The Wharton School at the University of Pennsylvania, a Master of Engineering (M. Eng.) in Electrical Engineering from Cornell University, and a Bachelor of Science (B.S.) in Electrical Engineering from Valparaiso University.

Kimon Michaels, Ph.D., one of our founders, has served as Vice President, Products and Solutions since July 2010 and was designated as an Executive VP in February 2019. Dr. Michaels served as Vice President, Design for Manufacturability from June 2007 through June 2010. Prior to that, Dr. Michaels served as Vice President, Field Operations for Manufacturing Process Solutions from January 2006 through May 2007, and has been a Director since November 1995. From March 1993 through December 2005, he served in various vice presidential capacities. He also served as Chief Financial Officer from November 1995 to July 1998. Dr. Michaels received a B.S. in Electrical Engineering, and M.S. E.C.E. and a Ph.D. E.C.E. from Carnegie Mellon University.

Available Information

We file or furnish various reports, such as registration statements, periodic and current reports, proxy statements and other materials with the SEC. Our Internet website address is www.pdf.com. You may obtain, free of charge on our website, copies of our annual reports on Form 10-K, quarterly reports on Form 10-Q, current reports on Form 8-K, and amendments to those reports filed or furnished pursuant to Section 13(a) or 15(d) of the Exchange Act, as soon as reasonably practicable after we electronically file such material with, or furnish it to, the SEC. The Company's website address provided is not intended to function as a hyperlink, and the information on the Company's website is not, and should not be considered, part of this Annual Report on Form 10-K and is not incorporated by reference herein.

The SEC maintains a Web site (<http://www.sec.gov>) that contains reports, proxy and information statements and other information regarding issuers, such as us, that file electronically with the SEC.

Item 1A. Risk Factors

We invest significant resources into research and development to pursue new product and technology initiatives, including our DFI system and Exensio platform, and if we invest more resources in research and development than anticipated or fail to successfully carry out these initiatives on the expected timeline or at all, our business, financial condition, or results of operations could be adversely impacted.

As part of the evolution of our business, we have made substantial investments in research and development efforts to develop new products, including our DFI system and Exensio software platform, as well continued investment to enhance existing products. New competitors, technological advances in the semiconductor industry or by competitors, our entry into new markets, or other competitive factors may require us to invest significantly greater resources than we anticipate. If we are required to invest significantly greater resources than anticipated without a corresponding increase in revenue, our operating results could decline. The technologies or products that we invest in may later not be sought after by semiconductor companies. In this event, we would not recoup our investment and our results would suffer. If we are unable to anticipate technological changes in our industry by introducing new or enhanced products in a timely and cost-effective manner, or if we fail to introduce products that meet market demand, we may lose our competitive position, our products may become obsolete, and our business, financial condition or results of operations could be adversely affected. Additionally, our periodic research and development expenses may be independent of our level of revenue, which could negatively impact our financial results.

Our sales cycle is lengthy and customers may delay entering into contracts or decide not to adopt our products or solutions after we have performed services or provided evaluation licenses, which could result in delays in recognizing revenue and negatively impact our results of operations in a quarter or result in lower revenue than we expected if a contract is not consummated at all.

On-going negotiations and evaluation projects for new products, with new customers or in new markets may not result in significant revenues for us if we are unable to close new engagements on terms favorable to us, in a timely manner, or at all. Unexpected delays in our sales cycle could cause our revenues to fall short of expectations. Further, the timing and length of negotiations required to enter into agreements with our customers and the ultimate enforcement of complex negotiated contractual provisions as we intended is difficult to predict. If we do not successfully negotiate certain key complex contractual provisions, there are disputes regarding such provisions, or they are not enforceable as we intended, our revenues and results of operations would suffer. Further, our customers sometimes delay starting negotiations until they begin developing a new process, need to insert a new product, or experience specific yield issues. This means that on occasion we have, and may continue to provide technology and services under preliminary documentation before executing the final contract. In these cases, we would not recognize revenue and may defer associated costs until execution of the final contract, which, if significant, could negatively impact our results of operations in the periods before we execute the final contract. Further, if we were to incur significant effort and then fail to enter into a final contract, we would have to write-off such deferred costs in the period in which the negotiations ended, which would decrease our costs and expenses and could result in significant operating losses.

Our fixed-fee services or product or system installation/configurations may take longer than budgeted, which could slow our revenue recognition and may also result in a loss contract or a claim of breach by our customers, which would negatively affect our operating results.

Our fixed-fee services, including in particular IYR, require a team of engineers to collaborate with our customers to address complex issues by using our software and other technologies, and the installation and configuration of our software into our customers' fabrication and test/assembly facilities requires experienced engineers working with our customers on active foundry and test/assembly equipment.

We must estimate the amount of resources needed to complete both of these types of services in order to estimate when the engineers will be able to commence the next engagement. In addition, our accounting for contracts with such services, which generate fixed fees, sometimes requires adjustments to profit (loss) based on revised estimates during the performance of the contract. These adjustments may have a material effect on our results of operations in the period in which they are made. The estimates giving rise to these risks, which are inherent in fixed-price contracts, include the forecasting of costs and schedules, and contract revenues related to contract performance. If we significantly fail to meet a customer's expectations in either case, the customer could claim that we breached our obligations, which could result in lost revenue and increased expenses.

Our ability to sell our products, systems, and solutions depends in part on the quality of our support and services offerings, and the failure to offer high-quality support and services could negatively affect our sales and results of operations.

Once our software products are integrated within our customers' hardware and software systems, our customers may depend on our support organization to resolve any issues relating to our products. Further, in connection with delivering our software as a service, which requires us to maintain adequate server hardware and internet infrastructure, including system redundancies, we will need to meet contractual uptime obligations. A high level of system and support is critical for the successful marketing and sale of our products. If we do not effectively provide subscription access to our SaaS customers, assist our customers in deploying our products, succeed in helping our customers quickly resolve post-deployment issues, and provide effective ongoing support and data security, we may face contractual penalties or customers may not renew subscriptions or services in the future, which would negatively impact our results of operations. In addition, due to our international operations, our system and support organization faces challenges associated with delivering support, hours that support is available, training, and documentation where the user's native language may not be English. If we fail to maintain high-quality support and services and adequately address our customers' support needs, our customers may choose our competitors' products instead of ours in the future, which would negatively affect our revenues and results of operations.

Defects in our proprietary technologies, hardware and software tools, and failure to effectively remedy any such defects could decrease our revenue and our competitive market share.

If the software, hardware, or proprietary technologies we provide to customers contain defects that negatively impact customers' ability to use our systems or software, increase our customers' cost of goods sold and time-to-market or damage our customers' property, these defects could significantly decrease the market acceptance of our solutions or results in warranty or other claims. We must adequately train our new personnel, especially our client service and technical support personnel, to effectively and accurately, respond to and support our customers. If we fail to do this, it could lead to dissatisfaction among our customers, which could slow our growth. Further, the cost of support resources required to remedy any defects in our technologies, hardware, or software tools could exceed our expectations. Any actual or perceived defects with our software, hardware, or proprietary technologies may also hinder our ability to attract or retain industry partners or customers, leading to a decrease in our revenue. These defects are frequently found during the period following introduction of new software, hardware, or proprietary technologies or enhancements to existing software, hardware, or proprietary technologies. Our software, hardware, and proprietary technologies may contain errors not discovered until after customer implementation of the silicon design and manufacturing process recommended by us. If our software, hardware, or proprietary technologies contain errors or defects, it could require us to expend significant resources to remedy these problems or defend/indemnify claims, which could reduce margins and result in the diversion of technical and other resources from our other customer implementations and development efforts.

Inadvertent disclosure of our customers' confidential information or our failure to comply with our customers' security rules, including for cloud-based solutions or on-site access could result in costly litigation, cause us to lose existing and potential customers, or negatively impact on-going business with existing customers.

Our customers consider their product yield information and other confidential information, which we must collect in the course of our engagement with the customer or through our software tools, to be extremely competitively sensitive, including data and personal data about our customers' employees necessary to administer the licenses. Many of our customers have strict security rules for on-site access to, or hosting, to their confidential information. If we suffered an unauthorized intrusion or we inadvertently disclosed or were required to disclose this information, or if we fail to adequately comply with customers' security protocols for accessing or hosting confidential information, we would likely lose existing and potential customers, could be subject to costly litigation, or our on-going business could be negatively impacted. Insurance to cover such situations is costly and will increase our costs and may not fully cover our exposure. In addition, to avoid potential disclosure of confidential information to competitors, some of our customers may, in the future, ask us not to work with key products or processes, which could limit our revenue opportunities.

We generate a significant portion of our revenues from a limited number of customers, and a large percentage of our revenues from a single customer, so decreased business with, our the loss of, any one of these customers, or pricing pressure, or customer consolidation could significantly reduce our revenues or margins and negatively impact results of operations.

Historically, we have had a small number of large customers for our IYR solutions and that contribute significant Gainshare royalties. In the year ended December 31, 2019, one customer, GlobalFoundries, accounted for 31% of our revenues. We could lose a customer due to its decision not to engage us on future process nodes, its negotiation or decision to reduce the scope of our services or technology under contract (which is permitted in one of our customer contracts if the customer's business materially adversely changes), its decision not to develop its own future process node, or as a result of industry factors, including but not limited to reduced manufacturing volume or consolidation. During 2018, a major customer announced that it was suspending indefinitely the development and production of its 7nm technology node. This customer's decision has negatively impacted our Integrated Yield Ramp revenues, and future Integrated Yield Ramp revenues will be negatively affected in the long-term as such revenues would have included the Gainshare from this contract but now will not since Gainshare is based on the customer's future production, which will not occur. Consolidation among our customers could also lead to increased customer bargaining power, or reduced customer spending on software and services. Further, new business may be delayed if a key customer uses its leverage to push for terms that are worse for us and we delay entering into the contract to negotiate for better terms, in which case revenue in any particular quarter or year may fail to meet expectations. Also, the loss of any of these customers or the failure to secure new contracts with these customers could further increase our reliance on our remaining customers. Further, if any of our key customers default, declare bankruptcy or otherwise delay or fail to pay amounts owed, or we otherwise have a dispute with any of these customers, our results of operations would be negatively affected in the short term and possibly the long term. These events could cause significant fluctuations in results of operations because our expenses are fixed in the short term and it takes us a long time to replace customers or reassign resources.

If we do not continuously meet our development milestones of key research and development projects or if we cannot qualify our e-beam measurement tool at customers for inline wafer inspection on schedule or at all, or successfully commercialize our Design-for-Inspection system, our future market opportunity and revenues will suffer and our costs may not be recouped.

Certain use cases of our DFI system remain to be proven and the inline version is pending qualification by the first commercial customer. To date, we have invested significantly in the design and development of our eProbe tool and related intellectual property. If our key customer fails to renew or expand the number or use of the systems it is using, or new foundry customers fail to adopt our DFI system, our results will suffer. For example, in 2018 an early adopter of our DFI system at 7nm elected to exercise an early exit under the contract in connection with its decision to suspend indefinitely further development and production at 7nm, which negatively impacted the long-term revenue we expected under this contract and possibility for renewal or expansion. Also, if the results of our DFI system are not as we expect, we may not be able to successfully commercialize these technologies on schedule, or at all, and we may miss the market opportunity and not recoup our investment. Further, our eProbe tool may cause unexpected damage to wafers or delay processing wafers, which we could be liable for, or which may make customers unwilling to use it. If we are not able to create significant interest and show reliable and useful results without significant damage to wafers, our investment may not be recouped and our future results may suffer.

Decreases in wafer volumes at our customers' manufacturing sites or the volume of ICs that some of our customers are able to sell to their customers would cause our Gainshare royalty and, thus, Integrated Yield Ramp revenue to suffer.

Our Gainshare royalty is largely determined by wafer volumes at manufacturing sites covered by our contracts and, in some cases, the volume of an IC product that our customer is able to sell to its customers. Both of these factors are outside of our control. Further, some of our manufacturing customers' business is largely dependent on customers that use our manufacturing customer as a second or third source. If those customers consolidate and/or otherwise move the orders to manufacturing facilities not covered by our contracts, or suspend their manufacturing at covered facilities for any reason, including consolidation, our Gainshare royalty will decrease, which could cause Integrated Yield Ramp revenues to fail to meet expectations. Reduced demand for semiconductor products decreases the volume of wafers and, in some cases, products our customers are able to sell, which would also directly decrease our Gainshare royalty. For example, 28nm volumes were lower in 2019 than expected, which negatively impacted our results. Also, our customers may unilaterally decide to implement changes to their manufacturing processes during the period that is covered by Gainshare, which could negatively affect yield results and, thus, our Integrated Yield Ramp revenue.

Since we currently work on a small number of large projects at specified manufacturing sites and, in some cases, on specific IC products, our results of operations are adversely affected by negative changes at those sites or in those products, including slowdowns in manufacturing due to external factors such as the spread of the coronavirus in China. Also, if wafer orders from sites covered by our contracts are not secured by our customers, if an end product does not achieve commercial viability, if a process line or, in some cases, a specific product, does not achieve significant increases in yield or sustain significant volume manufacturing during the time we receive Gainshare, revenues associated with such volumes or products would be negatively impacted. This could significantly reduce our Integrated Yield Ramp revenue and results of operations could fail to meet expectations. In addition, if we work with two directly competitive manufacturing facilities or products, volume in one may offset volume, and thus any of our related Gainshare, in the other facility or product.

We face operational and financial risks associated with international operations that could negatively impact our revenues.

We derive over half of our revenues from sales outside of the United States and we expect our international business to continue to grow, in particular in China. We have in the past expanded and reorganized, at different times, our operations, including international operations, and may in the future continue such expansion or reorganization by establishing or restructuring international subsidiaries, offices, or contractor relationships in locations, if and when, deemed appropriate by our management. Thus, the success of our business is subject to risks inherent in doing business internationally, including in particular:

- our growth in China is dependent upon continued investments in the semiconductor industry by both private and public entities within China. Should circumstances change such that the level of investments are substantially reduced, our future growth potential may be limited;
- some of our key engineers and other personnel are foreign nationals and they may not be permitted access to certain technical information under U.S. export laws or by certain of our customers and may have difficulty gaining access to the United States and other countries in which our customers or our offices may be located and it may be difficult for us to recruit and retain qualified technical and managerial employees in foreign offices;
- ineffective or inadequate protection or enforcement of our intellectual property in foreign jurisdictions;
- greater difficulty in collecting account receivables resulting in longer collection periods, bad debt, and increased cost to collect;
- language and other cultural differences may inhibit our sales and marketing efforts and create internal communication problems among our U.S. and foreign teams, increasing the difficulty of managing multiple, remote locations and negatively impacting sales and revenue;
- compliance with, inconsistencies among, and unexpected changes in, a wide variety of foreign laws and regulatory environments with which we are not familiar, including, among other issues, with respect to employees, personal data, tax, protection of our IP, and a wide variety of operational regulations and trade and export controls under domestic, foreign, and international law;
- currency risk due to the fact that certain of our payables and for our international offices are denominated in the foreign currency, including the Euro, Yen, and RMB, while virtually all of our revenues is denominated in U.S. dollars, or in the event a larger portion of our revenues becomes denominated in foreign currencies, we would be subject to a potentially significant exchange rate risk;
- inadequate local infrastructure that could result in business disruptions;
- additional taxes, interest, and potential penalties, and uncertainty around changes in tax laws of various countries;
- quarantine, private travel limitation, or business disruption in regions affecting our operations, stemming from actual, imminent or perceived outbreak of human pandemic or contagious disease, including the coronavirus; or
- economic or political instability, including but not limited to armed conflict, terrorism, interference with information or communication of networks or systems, and the resulting disruption to economic activity and business operations.

Further, our employees and contractors include professionals located in various international locations, including Shanghai, China, who provide primarily CV test chip-related services, and Ramallah, Palestine, who provide software-related development, quality assurance, maintenance, and other technical support services for certain of our software products. Political changes, including policies regarding export control, that affect these or other international operations could disrupt or limit the work our employees and contractors are able to perform, and thus negatively affect the range of services we are able to provide our customers or our cost for such services.

The spread of COVID-19 coronavirus from China has affected the manufacturing and shipment of goods. In January 2020, the Chinese government imposed certain restrictions on the movement of people and goods to limit the spread of the coronavirus in and around Wuhan. While our China operations are not located in Wuhan, our Shanghai office was temporarily shut down, and the restrictions have limited the ability of our local employees to travel to customer sites or visit our other offices. An extended closure of our customers' plants as a result of efforts to limit the spread of COVID-19 in China could adversely impact our business.

In addition, our global operations are subject to numerous U.S. and foreign laws and regulations, including those related to anti-corruption, tax, corporate governance, imports and exports, financial and other disclosures, privacy and labor relations. These laws and regulations are complex and may have differing or conflicting legal standards, making compliance difficult and costly. In addition, there is uncertainty regarding how proposed, contemplated or future changes to these complex laws and regulations could affect our business. We may incur substantial expense in complying with the new obligations to be imposed by these laws and regulations, and we may be required to make significant changes in our business operations, all of which may adversely affect our revenues and our business overall. If we violate these laws and regulations we could be subject to fines, penalties or criminal sanctions, and may be prohibited from conducting business in one or more countries. There can be no assurance that our policies and procedures will ensure compliance with these laws and regulations, or that employees, contractors, agents or partners will not violate such laws and regulations. A significant violation could have a significantly negatively impact our sales opportunities, operations, and financial results.

Our success depends upon our ability to effectively plan and manage our resources and restructure our business through rapidly fluctuating economic and market conditions, which actions may have an adverse effect on our financial and operating results.

Our ability to successfully offer our products and services in a rapidly evolving market requires an effective planning, forecasting, and management process to enable us to effectively scale and adjust our business and business models in response to fluctuating market opportunities and conditions. For example, while we have increased investment in our business by, for example, increasing headcount, acquiring companies, and increasing our investment in R&D, sales and marketing, and other parts of our business from time to time, including 2018, we initiated a restructuring plan to reduce expenses and align our operations with evolving business needs. Some of our expenses related to such efforts are fixed costs that cannot be rapidly or easily adjusted in response to fluctuations in our business or numbers of employees. Rapid changes in the size, alignment or organization of our workforce, including sales account coverage, could adversely affect our ability to develop and deliver products and services as planned or impair our ability to realize our current or future business and financial objectives. Our ability to achieve the anticipated cost savings and other benefits from our restructuring initiatives within the expected time frame is subject to many estimates and assumptions, which are subject to significant economic, competitive and other uncertainties, some of which are beyond our control. If these estimates and assumptions are incorrect, if we are unsuccessful at implementing changes, or if other unforeseen events occur, our business and results of operations could be adversely affected.

Global economic conditions or semiconductor market conditions could materially adversely impact demand for our products and services, decrease our sales, or delay our sales cycle.

Our customers are global semiconductor companies, which means that our operations and performance depend significantly on worldwide economic conditions as well as semiconductor market specific changes. Uncertainty about global economic conditions could result in customers postponing purchases of our products and services, including in response to tighter credit, unemployment, negative financial news and/or declines in income or asset values and other macroeconomic factors, which could have a material negative effect on demand for our products and services and, accordingly, on our business, results of operations or financial condition. For example, the timing of the build-out of the semiconductor market in China depends significantly on governmental funding on both local and national levels and a delay in this funding could negatively affect our revenues. For further example, any economic and political uncertainty caused by the United States tariffs imposed on goods from China, among other potential countries, and any corresponding tariffs from China or such other countries in response, may negatively impact demand and/or increase the cost for our products. Similarly, the spread of the COVID-19 coronavirus in China or in other nations could cause a slowdown in the global

economy and demand for our products and services. Further, the semiconductor industry historically has been volatile with up cycles and down cycles, due to sudden changes in customers' manufacturing capacity requirements and spending, which depend in part on capacity utilization, demand for customers' IC products by consumers, inventory levels relative to demand, and access to affordable capital. As a result of the various factors that affect this volatility, the timing and length of any cycles can be difficult to predict and could be longer than anticipated. Any of these events could negatively affect our revenues and make it challenging for us to forecast our operating results, make business decisions, and identify the risks that may affect our business, financial condition and results of operations. Customers with liquidity issues may also lead to additional bad debt expense.

If we fail to protect our intellectual property rights, customers or potential competitors may be able to use our technologies to develop their own solutions, which could weaken our competitive position, reduce our revenues, or increase our costs.

Our success depends largely on the proprietary nature of our technologies. Our contractual, patent, copyright, trademark, and trade secret protection may not be effective against any particular threat or in any particular location. Our pending patent applications may not result in issued patents, and even if issued, they may not be sufficiently broad to protect our proprietary technologies. Some foreign countries do not currently provide effective legal protection for intellectual property and our ability to prevent the unauthorized use of our products in those countries is therefore limited. Our trade secrets may also be stolen, otherwise become known, or be independently developed by competitors. Litigation may be necessary from time to time to enforce our IP rights or to determine the validity and scope of the proprietary rights of others. As a result of any such litigation, we could lose our proprietary rights and incur substantial unexpected operating costs. Litigation could also divert our resources, including our managerial and engineering resources. If we are unable to exclude others from using our proprietary technologies and methods without compensation to us, through litigation or otherwise, it could impede our ability to grow our business and our revenues may suffer.

If we do not effectively manage, support, and safeguard our worldwide information systems, and integrate recent and planned growth, our business strategy may fail.

We are heavily reliant on our technology and infrastructure, as well as the public cloud to an increasing degree, to provide our products and services to our customers. We have experienced in the past, and may experience in the future, interruptions in our information systems on which our global operations depend or unplanned downtime of the infrastructure that delivers our SaaS products. Further, we may face attempts by others to gain unauthorized access through the Internet to our information technology systems whether hosted by us or service providers, to intentionally hack, interfere with, or cause physical or digital damage to or failure of such systems (such as significant viruses or worms), which attempts we or they may be unable to prevent. Our security measures may also be breached due to employee errors, malfeasance, or otherwise. For example, in the first quarter of 2020, one of our cloud installations suffered an intrusion due to a vulnerability discovered and published by the provider of the Citrix ADC that was part of our installation. Third parties may also attempt to influence employees, users, suppliers or customers to disclose sensitive information in order to gain access to our, our customers' or business partners' data. Additionally, third parties with whom we work, such as vendors or developers, may violate applicable laws or our policies and such violations can place personal information of our customers at risk.

We or our service providers could be unaware of an incident or its magnitude and effects until after it is too late to prevent it and the damage it may cause. The theft, unauthorized use, or a cybersecurity attack that results in the publication of our trade secrets and other confidential business information as a result of such an incident could negatively affect our competitive position, the value of our investment in product or research and development, and third parties might assert against us or our customers claims related to resulting losses of confidential or proprietary information or end-user data and/or system reliability. In any such event, our business could be subject to significant disruption, which could impact our revenues or cause customers to cease doing business with us, and we could suffer monetary and other losses, including reputational harm, which costs we may not be able to recover from our service providers. Our operations are dependent upon our ability to protect our technology infrastructure against damage from business continuity events that could have a significant disruptive effect on our operations.

In addition, we collect, use, store or disclose (collectively, "process") an increasingly large amount of personal information, including from employees and customers, in connection with the operation of our business. The personal information we process is subject to an increasing number of federal, state, local and foreign laws regarding privacy and data security, as well as contractual commitments. Any failure or perceived failure by us to comply with such obligations may result in governmental enforcement actions, fines, litigation, or public statements against us by consumer advocacy groups or others and could cause our customers to lose trust in us, which could have an adverse effect on our reputation and business. Additionally, changes to applicable privacy or

data security laws could impact how we process personal information, and therefore limit the effectiveness of our solutions or our ability to develop or deliver new products or services. For example, the European Union General Data Protection Regulation, which became fully effective on May 25, 2018, imposes stringent data protection requirements and provides for significant penalties for noncompliance of up to the greater of €20 million or four percent of worldwide annual revenues. Regulation is also increasingly occurring at the U.S. state level to supplement federal legislative action or inaction, as indicated by the California Consumer Privacy Act (CCPA), which becomes enforceable in 2020 and may apply to our products, services, and data.

Additionally, we must frequently expand our internal information system to meet increasing demand in storage, computing and communication, which may result in increased costs. Our internal information system is expensive to expand and must be highly secure due to the sensitive nature of our customers' information that we transmit. Building and managing the support necessary for our growth places significant demands on our management and resources. These demands may divert these resources from the continued growth of our business and implementation of our business strategy.

If we are not able to retain, attract, motivate, and strategically locate talented employees, including some key executives, our business may suffer.

Our success and competitiveness depend on our ability to retain, attract, motivate, and strategically locate in our offices around the globe, talented employees, including some of our key executives. Achieving this objective may be difficult due to many factors, including fluctuations in global economic and industry conditions, changes in our management or leadership, the hiring practices at our competitors or customers, cost reduction activities, and the effectiveness of our compensation programs, including equity-based programs. Further, we have had, and expect to continue to have, difficulty in obtaining visas permitting entry for some of our employees that are foreign nationals into the United States, and delays in obtaining visas permitting entry into other key countries, for several of our key personnel, which disrupts our ability to strategically locate our personnel. In recent years, the United States has increased the level of scrutiny in granting H-1(b), L-1 and other business visas. The Trump administration has indicated that immigration reform is a priority. Compliance with United States immigration and labor laws could require us to incur additional unexpected labor costs and expenses or could restrain our ability to retain skilled professionals. If we lose the services of certain of our key executives or a significant number of our engineers, it could disrupt our ability to implement our business strategy. If we do not successfully attract, retain, and motivate key employees, including key executives, we may be unable to realize our business objectives and our operating results may suffer.

Our earnings per share and other operating results may vary quarter to quarter, which could result in not meeting investors' expectations and cause our stock price to drop.

Our stock price has fluctuated widely during the last few years, from a low closing price of \$7.73 per share in October 2018 to a high closing price of \$24.16 per share in December 2016. A factor in the volatility may be that our historical quarterly operating results have fluctuated. Our future quarterly operating results will likely fluctuate from time to time and may not meet the expectations of securities analysts and investors in some future period, which could cause our stock price to decrease again. A significant reduction in our stock price negatively impacts our ability to raise equity capital in the public markets and increases the cost to us, as measured by dilution to our existing shareholders, of equity financing. In addition, the reduced stock price also increases the cost to us, in terms of dilution, of using our equity for employee compensation or for acquisitions of other businesses. A greatly reduced stock price could also have other negative results, including the potential loss of confidence by employees, the loss of institutional investor interest, a hostile take-over bid, and fewer business development opportunities. Also, significant volatility in the stock price could be followed by a securities class action lawsuit, which could result in substantial costs and a diversion of our management's attention and resources.

Competition in the market for data analytics and related systems and services may intensify in the future, which could impede our ability to grow or execute our strategy.

Competition in our market may intensify in the future, which could slow our ability to grow or execute our strategy and could lead to increased pricing pressure, negatively impacting our revenues. Our current and potential customers may choose to develop their own solutions internally, particularly if we are slow in deploying our solutions or improving them to meet market needs. These and other competitors may be able to operate with a lower cost structure than our engineering organization, which would give any such competitor's products a competitive advantage over our solutions. We currently face indirect competition from the internal groups at IC companies and some direct competition from providers of (i) yield management and/or prediction systems, such as KLA-Tencor, Siemens AG ("Siemens"), Rudolph Technologies, Inc. ("Rudolph"), Synopsys, Inc., and Qualtera, (ii) semiconductor manufacturing software, such as Applied Materials, Inc., BISTel Inc., Invantest, Inc., Optimal+, Rudolph, and Siemens and, (iii) inline inspection, metrology and electrical test equipment providers, such as Applied Materials and Keysight Technologies, Inc.

Further, we may compete with the products or offerings of these named companies or additional companies if we expand our offerings through acquisition or development. There may be other providers of commercial solutions for systematic IC yield and performance enhancement of which we are not aware. Further, some providers of yield management software or inspection equipment may seek to broaden their product offerings and compete with us. In addition, we believe that the demand for solutions that address the need for better integration between the silicon design and manufacturing processes may encourage direct competitors to enter into our market. For example, large integrated organizations, such as IDMs, electronic design automation software providers, IC design service companies or semiconductor equipment vendors, may expand their product offerings or decide to spin-off a business unit to compete with us. Other potential competitors include fabrication facilities that may decide to offer solutions competitive with ours as part of their value proposition to their customers. If these potential competitors change the pricing environment or are able to attract industry partners or customers faster than we can, we may not be able to grow and execute our strategy as quickly or at all.

Measurement of our Gainshare royalties and other variable consideration requires data collection and customers' use of estimates in some cases and is subject to customers' agreement and is later offset if actual data differ from customers' estimates, which can result in uncertainty and cause quarterly results to fluctuate.

We can only recognize Gainshare royalty once we have reached agreement with our customers on their level of yield performance improvements and quarterly agreements are sometimes based on estimates of volume results each quarter. Measuring the amount of yield improvement is inherently complicated and dependent on our customers' internal processes, thus, there may be uncertainty as to some components of measurement. Also, some variable considerations can be highly susceptible to delays in the customer measurement of key factors such as reporting volumes results and level of yield. Therefore, we may have to estimate revenue related to contingent variable fees or usage-based or sales-based royalties prior to the receipt of performance reports, such as Gainshare acknowledgements, or other related information from customers. These estimates are subject to judgment to evaluate whether it is probable that a significant revenue reversal will not occur in future periods, which could result in our recognition of less Integrated Yield Ramp revenue than expected in any particular period and later offset when actual results become available.

We have customers with past due receivable balances and our failure to collect a significant portion of such balances could adversely affect our cash, require us to write-off receivables, or increase our bad debt allowance.

If we fail to collect receivable balances when due, our cash will decrease and we may have to write-off a portion or all of such receivables or increase our bad debt allowance. Our accounts receivable balance, net of allowances, was \$40.7 million and \$51.6 million as of December 31, 2019, and 2018, respectively. Three customers accounted for 53% of our gross accounts receivable as of December 31, 2019 and two customers accounted for 56% our gross accounts receivable as of December 31, 2018, and one customer accounted for 31%, and 37% of our revenues for 2019, and 2018, respectively. The allowance for doubtful accounts was \$0.2 million and \$0.3 million as of December 31, 2019 and 2018, respectively. We generally do not require collateral or other security to support accounts receivable. Despite the financial ability of these customers to pay for on-going services by PDF under valid contracts, customers may delay payments. Our allowances for potential credit losses, if any, could be insufficient, and we may need to adjust our allowance for doubtful accounts from current estimates or write-off receivables depending on such claims in the future. If we are forced to pursue legal remedies to collect receivables, our business relationship and future business with these customers could suffer.

We have experienced losses in the past and we may incur losses again in the future.

We have experienced losses in the past, and we may incur losses again in the future if we are not able to adequately control our costs or if total revenues fail to exceed costs. In addition, virtually all of our quarterly operating expenses are fixed, so any shortfall in anticipated quarterly revenues could significantly reduce our operating results below expectations. Our accumulated deficit was \$35.9 million as of December 31, 2019. We expect to continue to incur significant expenses in connection with:

- funding for research and development;
- restructuring costs related to our cost control and management efforts;
- expansion of our sales and marketing efforts; and
- additional non-cash charges relating to amortization and stock-based compensation.

Our technologies could infringe the intellectual property rights of others, causing costly litigation and the loss of significant rights.

Significant litigation regarding intellectual property rights exists in the semiconductor industry. It is possible that a third party may claim that our technologies infringe their intellectual property rights or misappropriate their trade secrets. For example, in 2019, one of our Exensio customers notified us that they had been named in a lawsuit alleging, among other things, that their use of Exensio Control Distributed infringed the patent of a third party. Any claim, even if without merit, could be time consuming to defend, result in costly litigation, or require us to enter into royalty or licensing agreements, which may not be available to us on acceptable terms, or at all. A successful claim of infringement against us in connection with the use of our technologies could adversely affect our business.

Changes in effective tax rates could positively affect our earnings, thereby raising investors' expectations, while the final tax rates that are determined could be significantly higher, thereby lowering our earnings and causing us to miss investors' expectations, which could cause our stock price to drop.

We conduct our business globally and, as a result, are subject to taxation in the United States and foreign countries. Our future tax rates could be affected by numerous factors, including recent changes in tax laws or the interpretation of such tax laws, insufficient taxable income to realize deferred tax assets, and changes in accounting policies. Our filings are subject to reviews or audit by the Internal Revenue Service and state, local and foreign taxing authorities. We cannot be sure that any final determination in an audit would not be materially different than the treatment reflected in our historical income tax provisions and accruals. If additional taxes are assessed as a result of an audit, there could be a significant negative effect on our income tax provision and our operating results in the period or periods for which that determination is made. Any changes in our geographical earnings mix in various tax jurisdictions, including those resulting from transfer pricing adjustments, could materially increase our effective tax rate.

Future events may impact our deferred tax asset position, including the utilization of net operating loss and tax credit carryforwards.

If our judgment and assumptions about our ability to utilize deferred tax assets and our need for valuation allowances based on available evidence fails to change to reflect changes in tax laws or variances between future projected operating performance and actual results, we may not be able to utilize net operating loss and tax credit carryforwards as we expect. If the valuation allowance for deferred tax assets that we determine, based on available evidence at the time the determination is made, is later adjusted (either by an increase or a decrease), the deferred tax asset valuation allowance may change and our results of operations may be negatively impacted.

Our business could be negatively affected as a result of actions of activist shareholders, and such activism could impact the trading value of our securities.

In recent years, shareholder activists have become involved in numerous public companies, including our company. Shareholder activists frequently propose to involve themselves in the governance, strategic direction, and operations of a company. Such proposals may disrupt our business, increase our expenses, and divert the attention of our Board of Directors and our management and employees, and any perceived uncertainties as to our future direction resulting from such a situation could result in the loss of potential business opportunities, interfere with our ability to execute our strategic plan be exploited by our competitors, cause concern to our current or potential customers, and make it more difficult to attract and retain qualified personnel and business partners, all of which could adversely affect our business. A proxy contest for the election of directors at our annual meeting could also require us to incur significant legal fees and proxy solicitation expenses. In addition, actions of activist shareholders may cause significant fluctuations in our stock price based on temporary or speculative market perceptions or other factors that do not necessarily reflect the underlying fundamentals and prospects of our business.

Item 1B. Unresolved Staff Comments

None.

Item 2. Properties

Our principal executive offices are located in Santa Clara, California, where we lease approximately 20,800 square feet of office space expiring in August 2028. We also have facilities or offices in Milpitas, California; La Jolla, California; Pittsburgh, Pennsylvania; Richardson, Texas; Shanghai, China; Canada; France; Germany; Italy; Japan; Korea; and, Taiwan.

We believe our existing and planned facilities are adequate to meet our current needs and are being utilized consistently with our past practice. We consistently look for opportunities to minimize costs related to office space through improved efficiencies and intend to make changes to leased facilities in the future as appropriate to reflect changes in worldwide operations and headcount.

Item 3. Legal Proceedings

From time to time, we are subject to various claims and legal proceedings that arise in the ordinary course of business. We accrue for losses related to litigation when a potential loss is probable and the loss can be reasonably estimated in accordance with FASB requirements. As of December 31, 2019, we were not party to any material legal proceedings, thus no loss was probable and no amount was accrued.

Item 4. Mine Safety Disclosures

None.

PART II

Item 5. Market For Registrant’s Common Equity, and Related Stockholder Matters and Issuer Purchases of Equity Securities

Our common stock trades on the Nasdaq Global Market under the symbol “PDFS.” As of March 6, 2020, we had approximately 31 stockholders of record. The number of stockholders of record does not include individuals whose stock is in nominee or “street name” accounts through brokers.

Dividend Policy

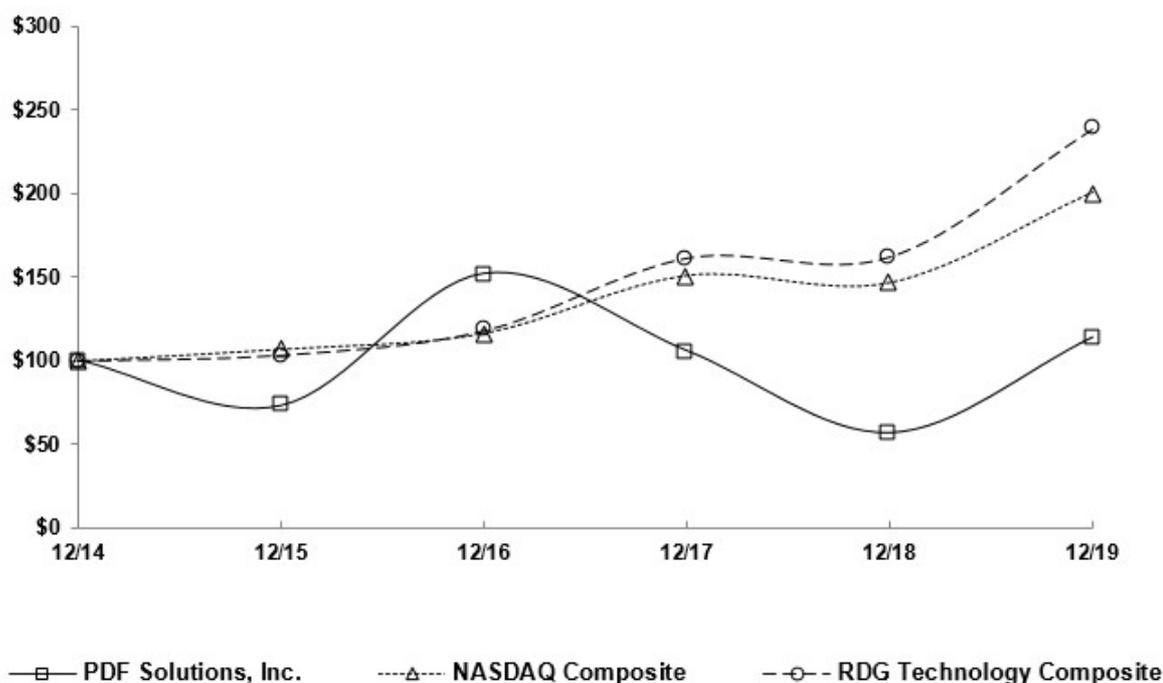
No cash dividends were declared or paid in 2019 and 2018. We currently intend to retain all available funds to finance future internal growth and product development and stock repurchases and therefore do not anticipate paying any cash dividends on our common stock for the foreseeable future.

Stock Performance Graph

The following graph and tables compare the cumulative total stockholder return data for our stock since December 31, 2014, to the cumulative return over such period of (i) The Nasdaq Composite Index and (ii) the RDG Technology Composite Index. The graph assumes that \$100 was invested on December 31, 2014. The graph and tables further assume that such amount was initially invested in the Common Stock of the Company at a per share price of \$14.86 (closing price on December 31, 2014) and that any dividends were reinvested. This performance graph and the corresponding tables are not “soliciting material,” are not deemed filed with the SEC and are not to be incorporated by reference in any filing by us under the Securities Act or the Exchange Act whether made before or after the date hereof and irrespective of any general incorporation language in any such filing. The stock price performance on the following graph and tables is not necessarily indicative of future stock price performance.

COMPARISON OF 5 YEAR CUMULATIVE TOTAL RETURN*

Among PDF Solutions, Inc., the NASDAQ Composite Index and the RDG Technology Composite Index



*\$100 invested on 12/31/14 in stock or index, including reinvestment of dividends.
Fiscal year ending December 31.

	12/14	12/15	12/16	12/17	12/18	12/19
PDF Solutions, Inc.	100.00	72.95	151.75	105.65	56.73	113.66
Nasdaq Composite Index	100.00	106.96	116.45	150.96	146.67	200.49
RDG Technology Composite Index	100.00	103.42	118.01	161.58	162.31	238.96

Purchases of Equity Securities by the Issuer and Affiliated Purchasers

On May 29, 2018, the Board of Directors adopted a new program (“2018 Program”) to repurchase up to \$25.0 million of the Company’s common stock both on the open market and in privately negotiated transactions over the next two years. During the year ended and as of December 31, 2019, the Company repurchased approximately 785,000 shares at an average price of \$12.43 per share, for a total price of \$9.8 million, under the 2018 Program. Under the 2018 program, as of December 31, 2019, \$15.2 million remained available for future repurchases million of the Company’s common stock.

There were no purchases made by or on behalf of the Company or any “affiliated purchaser” (as the term is defined in Rule 10b-18(a)(3) under the Exchange Act) of our common stock during the fourth quarter ended December 31, 2019.

Item 6. Selected Financial Data

The following selected consolidated financial information has been derived from the audited consolidated financial statements. The information set forth below is not necessarily indicative of results of future operations and should be read in conjunction with Item 7. “Management’s Discussion and Analysis of Financial Condition and Results of Operations” and the consolidated financial statements and notes to those statements included therein and in Part II of this Form 10-K.

	Year Ended December 31,				
	2019	2018	2017	2016	2015
	(In thousands, except per share amounts)				
Consolidated Statements of Comprehensive Income (Loss)					
Data:					
Total revenues	\$ 85,585	\$ 85,794	\$ 101,871	\$ 107,461	\$ 97,977
Costs and Expenses:					
Costs of revenues	33,474	42,803	47,521	44,448	39,023
Research and development	32,747	27,998	30,078	27,559	19,096
Selling, general and administrative	26,299	23,934	23,684	22,056	20,421
Amortization of other acquired intangible assets	609	435	398	432	196
Restructuring charges	92	576	—	—	—
Interest and other expense (income), net	(276)	(493)	264	10	(181)
Income (loss) before taxes	(7,360)	(9,459)	(74)	12,956	19,422
Income tax provision (benefit)	(1,942)	(1,743)	1,263	3,853	7,015
Net income (loss)	<u>\$ (5,418)</u>	<u>\$ (7,716)</u>	<u>\$ (1,337)</u>	<u>\$ 9,103</u>	<u>\$ 12,407</u>
Net income (loss) per share:					
Basic	<u>\$ (0.17)</u>	<u>\$ (0.24)</u>	<u>\$ (0.04)</u>	<u>\$ 0.29</u>	<u>\$ 0.39</u>
Diluted	<u>\$ (0.17)</u>	<u>\$ (0.24)</u>	<u>\$ (0.04)</u>	<u>\$ 0.28</u>	<u>\$ 0.39</u>
Weighted average common shares:					
Basic	<u>32,411</u>	<u>32,169</u>	<u>32,038</u>	<u>31,373</u>	<u>31,424</u>
Diluted	<u>32,411</u>	<u>32,169</u>	<u>32,038</u>	<u>32,431</u>	<u>32,164</u>

	December 31,				
	2019	2018	2017 (In thousands)	2016	2015
Consolidated Balance Sheets Data:					
Cash and cash equivalents	\$ 97,605	\$ 96,089	\$ 101,267	\$ 116,787	\$ 126,158
Working capital	119,580	137,693	144,263	151,757	148,795
Total assets	239,544	225,905	224,176	222,329	191,769
Long-term obligations	15,391	6,582	6,171	5,004	3,006
Total stockholders' equity	196,157	199,795	198,368	198,803	174,307

Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations

Overview

We offer products and services designed to empower engineers and data scientists across the semiconductor ecosystem to improve the yield, quality, and profitability of their products. We derive revenues from two sources: Analytics and Integrated Yield Ramp. Our offerings combine proprietary software, physical IP for IC designs, electrical measurement hardware tools, proven methodologies, and professional services. We primarily monetize our offerings through time-based license fees, contract revenue for professional services, and increasingly recently, software as a service (or SaaS). In some cases, especially on our historical IYR engagements, we also receive a value-based royalty that we call Gainshare. Our products, services, and solutions have been sold to IDMs, fabless semiconductor companies, foundries, OSATs, and system houses.

Industry Trend

Certain trends may affect our Analytics revenue. In particular, the confluence of Industry 4.0 (i.e. the fourth industrial revolution, or the automation and data exchange in manufacturing technologies and processes) and cloud computing (i.e. the on-demand availability of computing resources and data storage without direct active management by the user) is driving increased innovation in semiconductor and electronics manufacturing and analytics, as well as in the organization of IT networks and computing at those same companies. First, the ubiquity of wireless connectivity and sensor technology enables any manufacturing company to augment its factories and visualize its entire production line. In parallel, the cost per terabyte of data storage has continually decreased year to year. The combination of these two trends means that more data is collected and stored than ever before. Semiconductor companies are striving to analyze these very large data sets in real-time to make rapid decisions that measurably improve manufacturing efficiency and quality. In parallel, the traditional practice of on-site data storage, even for highly sensitive data, is changing. The ability to cost-effectively and securely store, analyze, and retrieve massive quantities of data from the cloud versus on-premise enables data to be utilized across a much broader population of users, frequently resulting in greater demands on analytics programs. The combination of these two trends means that cloud-based, analytic programs that effectively manage identity management, physical security and data protection are increasingly in demand for insights and efficiencies across the organizations of these companies. We believe that all these trends will continue for the next few years, and the challenges involved in adopting Industry 4.0 and secure cloud computing will create opportunities for companies that have a combination of advanced analytics capabilities, proven and established data infrastructures, and professional services to optimize their environment to customers' specialized needs.

Other trends may continue to affect our Integrated Yield Ramp revenue. The logic foundry market at the leading edge nodes, such as 10nm and 7nm, has undergone significant change over the past few years. The leading foundry continues to increase market share as other foundries have either suspended 7nm development, forecasted a later start of mass production, or started later than originally forecast in some cases. This trend will likely continue to negatively impact our Integrated Yield Ramp business on these nodes. Further, for many foundries, utilization rates for 28nm fabs remain suppressed. We expect most logic foundries to invest in derivatives of older process nodes, such as 28nm and 20nm, to extract additional value as many of their customers will not move to advanced nodes due to either technological barriers or restrictive economics. Foundries that participate at leading edge nodes are expected to continue to invest in new technologies such as memory, packaging, and multi-patterned and EUV lithography, as well as new innovations in process control and variability management. We expect China's investment in semiconductors to continue. In order for these trends to provide opportunities for us to increase our business in process control and electrical characterization, Chinese semiconductor manufacturers will need to increase their production volumes on advanced technology nodes and continue to engage foreign suppliers. As a result of these market developments, we have chosen to focus our resources and investments in products, services, and solutions for analytics.

There are other trends that may affect our business opportunities in general. For instance, the demand for consumer electronics, communications devices, and high performance computing continues to drive technological innovation in the semiconductor industry as the need for products with greater performance, lower power consumption, reduced costs and smaller size continues to grow with each new product generation. In addition, advances in computing systems and mobile devices have fueled demand for higher capacity memory chips. To meet these demands, IC manufacturers and designers are constantly challenged to improve the overall performance of their ICs by designing and manufacturing ICs with more embedded applications to create greater functionality while lowering power and cost per transistor. As this trend continues, companies will continually be challenged to improve process capabilities to optimally produce ICs with minimal random and systematic yield loss, which is driven by the lack of compatibility between the design and its respective manufacturing process. We believe that these difficulties will continue to create a need for all types of products and services that address yield loss across the IC product life cycle.

Financial Highlights

The following are our financial highlights for the year ended December 31, 2019:

- Total revenues were \$85.6 million, which was relatively flat compared to the year ended December 31, 2018. Analytics revenue was \$49.6 million, which was an increase of \$11.1 million, or 29%, compared to the year ended December 31, 2018. The increase in Analytics revenue was driven by higher business activity in licenses and services for Exensio Software, Exensio SaaS, DFI systems, and Characterization Vehicle systems and services. Integrated Yield Ramp revenue decreased \$11.3 million for the year ended December 31, 2019, compared to the year ended December 31, 2018, resulting primarily from lower hours worked across multiple contracts and customers and lower Gainshare royalties due to decline in customers' revenues at qualifying nodes.
- A Costs of Revenues reduction of \$9.3 million, was primarily driven by a reduction of \$9.0 million less in personnel-related costs due to fewer IYR engagements, which are typically labor intensive compared to software time-based license projects.
- Net loss was \$5.4 million, compared to \$7.7 million for the year ended December 31, 2018. The decrease in net loss was primarily attributable to a \$9.3 million decrease in cost of revenues, partially offset by a \$6.8 million increase in operating expenses as we continued to make investments in research and development and sales and marketing activities, and a \$0.2 million increase in tax benefits.
- Net loss per basic and diluted share was \$0.17, compared to net loss per basic and diluted share of \$0.24 for the year ended December 31, 2018, a decrease of \$0.07 per basic and diluted share.
- Cash, cash equivalents and investments increased \$1.5 million to \$97.6 million at December 31, 2019, from \$96.1 million at December 31, 2018, primarily due to the collection of significant past due accounts receivables during the third quarter of fiscal 2019, partially offset by cash used in investing activities related to the property and equipment purchased for the development our DFI initiative, expansion of our research and development laboratory and clean room, a payment for the acquisition of certain assets of StreamMosaic, Inc., a provider of artificial intelligence and machine learning solutions, and cash used in financing activities primarily due to repurchases of our common stock.

Critical Accounting Policies and Estimates

The preparation of financial statements and related disclosures in conformity with accounting principles generally accepted in the United States requires us to make judgments, assumptions, and estimates that affect the amounts reported in the Consolidated Financial Statements and accompanying notes. Notes 1 and 2 of Notes to Consolidated Financial Statements describe the significant accounting policies and methods used in the preparation of the Consolidated Financial Statements. We consider the accounting policies described below to be our critical accounting policies. These critical accounting policies are impacted significantly by judgments, assumptions, and estimates used in the preparation of the Consolidated Financial Statements and actual results could differ materially from the amounts reported based on these policies.

Revenue Recognition

We derive revenue from two sources: Analytics and Integrated Yield Ramp.

Analytics Revenue

Analytics revenue is derived from the following primary offerings: licenses and services for Exensio Software, Exensio SaaS, DFI and CV systems that do not include performance incentives based on customers' yield achievement.

Revenue from standalone Exensio Software is recognized depending on whether the license is perpetual or time-based. Perpetual (one-time charge) license software is recognized at the time of the inception of the arrangement when control transfers to the customers, if the software license is distinct from the services offered by us. Revenue from post-contract support is recognized over the contract term on a straight-line basis, because we are providing (i) support and (ii) unspecified software updates on a when-and-if available basis over the contract term. Revenue from time-based-licensed software is allocated to each performance obligation and is recognized either at a point in time or over time as follows. The license component is recognized at the time of the delivery of the software license, with the post-contract support component recognized ratably over the committed term of the contract. For contracts with any combination of licenses, support, and other services, distinct performance obligations are accounted for separately. For contracts with multiple performance obligations, we allocate the transaction price of the contract to each performance obligation on a relative basis using standalone selling price (or SSP) attributed to each performance obligation.

Revenue from Exensio SaaS arrangements, which allow for the use of a cloud-based software product or service over a contractually determined period of time without taking possession of software, is accounted for as subscriptions and is recognized as revenue ratably, on a straight-line basis, over the subscription period beginning on the date the service is first made available to customers.

Revenue from DFI and CV systems that do not include performance incentives based on customers' yield achievement is recognized primarily as services are performed. Where there are distinct performance obligations, we allocate revenue to all deliverables based on their standalone selling prices, or SSP. In such instances, we apply judgment to estimate the range of SSPs for each performance obligation. For these contracts with multiple performance obligations, we allocate the transaction price of the contract to each performance obligation on a relative basis using SSP attributed to each performance obligation. Where there are not discrete performance obligations, historically, revenue is primarily recognized as services are performed using a percentage of completion method based on costs or labor-hours inputs, whichever is the most appropriate measure of the progress towards completion of the contract. Due to the nature of the work performed in these arrangements, the estimation of percentage of completion method is complex subject to many variables that require significant judgement. Key factors reviewed by us to estimate costs to complete each contract are future labor and product costs and expected productivity efficiencies. If circumstances arise that impact the original estimates of revenues, costs, or the extent of progress toward completion, revisions to the estimates are made. Revisions to estimates over the course of a service contract may be made and are accounted for on a cumulative catch-up basis. These revisions may result in increases or decreases in estimated revenues or costs. Revisions in profit estimates are reflected in the period in which the conditions that require the revisions become known and can be estimated (cumulative catch-up method). Losses on fixed-price solution implementation contracts are recognized in the period when they become probable.

Integrated Yield Ramp Revenue

Integrated Yield Ramp revenue is derived from our IYR engagements, which include Gainshare or other performance incentives based on customers' yield achievement.

Revenue under these project-based contracts, which are delivered over a specific period of time typically for a fixed fee component paid on a set schedule, is recognized as services are performed using a percentage of completion. Similar to the services provided in connection with CV systems that are contributing to Analytics revenue, due to the nature of the work performed in these arrangements, the estimation of percentage of completion method is complex and subject to many variables that require significant judgement.

The Gainshare royalty contained in IYR contracts is a variable fee related to continued usage of our IP after the fixed-fee service period ends, based on the customers' yield achievement. Revenue derived from Gainshare is contingent upon our customers reaching certain defined production yield levels. Gainshare royalty periods are generally subsequent to the delivery of all contractual services and performance obligations. We record Gainshare as a usage-based royalty derived from customers' usage of intellectual property and record it in the same period in which the usage occurs.

Income Taxes

We are required to assess whether it is "more-likely-than-not" that we will realize our deferred tax assets. If we believe that they are not likely to be fully realizable before the expiration dates applicable to such assets, then to the extent we believe that recovery is not likely, we must establish a valuation allowance. The valuation allowance was approximately \$10.5 million and \$9.8 million as of December 31, 2019 and 2018 respectively, which was related to California R&D tax credits and California net operating losses related to an acquisition that we currently do not believe to be "more-likely-than-not" to be ultimately realized. If we conclude at a future financial reporting period that there has been a change in our ability to realize our California R&D credit and net operating loss carry forward deferred tax assets, and it is at such time "more-likely-than-not" that we will realize the tax credits before applicable expiration dates, our tax provision will decrease in the period in which we make such determination.

We evaluate our deferred tax assets for realizability considering both positive and negative evidence, including our historical financial performance, projections of future taxable income, future reversals of existing taxable temporary differences, tax planning strategies and any carryback availability. In evaluating the need for a valuation allowance, we estimate future taxable income based on management approved business plans. This process involves significant management judgment about assumptions that are subject to change from period to period based on changes in tax laws or variances between future projected operating performance and actual results. Changes in the net deferred tax assets, less offsetting valuation allowance, in a period are recorded through the income tax provision and could have a material impact on the Consolidated Statements of Comprehensive Loss.

Our income tax calculations are based on application of applicable U.S. federal, state or foreign tax law. Our tax filings, however, are subject to audit by the respective tax authorities. Accordingly, we recognize tax liabilities based upon our estimate of whether, and the extent to which, additional taxes will be due when such estimates are more-likely-than-not to be sustained. An uncertain income tax position will not be recognized if it has less than a 50% likelihood of being sustained. To the extent the final tax liabilities are different than the amounts originally accrued, the increases or decreases are recorded as income tax expense or benefit in the Consolidated Statements of Comprehensive Loss. At December 31, 2019, no deferred taxes have been provided on undistributed earnings from the Company's international subsidiaries. The Company intends to reinvest the earnings of its non-U.S. subsidiaries in those operations indefinitely. As such, the Company has not provided for any foreign withholding taxes on the earnings of foreign subsidiaries as of December 31, 2019. The earnings of the Company's foreign subsidiaries are taxable in the U.S. in the year earned under the Global Intangible Low-Taxed Income rules implemented under 2017 Tax Cuts and Jobs Act.

Software Development Costs

Internally developed software includes software developed to meet our internal needs to provide certain services to our customers. These capitalized costs consist of internal compensation related costs and external direct costs incurred during the application development stage and are amortized over their useful lives, which is generally five to six years. The costs to develop software that is marketed externally have not been capitalized as we believe our current software development process is essentially completed concurrent with the establishment of technological feasibility. As such, all related software development costs are expensed as incurred and included in research and development expense in our Consolidated Statements of Comprehensive Loss.

Stock-Based Compensation

Stock-based compensation is estimated at the grant date based on the award's fair value and is recognized on a straight-line basis over the vesting period, which for us, is generally four years. As stock-based compensation expense recognized is based on awards ultimately expected to vest, it has been reduced for estimated forfeitures. Forfeitures are estimated at the time of grant and revised, if necessary, in subsequent periods if actual forfeitures differ from those estimates.

We have elected to use the Black-Scholes-Merton option-pricing model for our stock option grants, which incorporates various assumptions including volatility, expected life and interest rates. The expected volatility is based on the historical volatility of our common stock over the most recent period commensurate with the estimated expected life of stock options. The expected life of an award is based on historical experience and on the terms and conditions of the stock awards granted to employees. The interest rate assumption is based upon observed Treasury yield curve rates appropriate for the expected life of stock options.

Valuation of Long-lived Assets including Goodwill and Intangible Assets

We record goodwill when the purchase consideration of an acquisition exceeds the fair value of the net tangible and identified intangible assets as of the date of acquisition. We perform an annual impairment assessment of goodwill during the fourth quarter of each calendar year or more frequently, if required to determine if any events or circumstances exist, such as an adverse change in business climate or a decline in the overall industry demand, that would indicate that it would more likely than not reduce the fair value of a reporting unit below its carrying amount, including goodwill. If events or circumstances do not indicate that the fair value of a reporting unit is below its carrying amount, then goodwill is not considered to be impaired and no further testing is required. If further testing is required, we perform a two-step process. The first step involves comparing the fair value of its reporting unit to its carrying value, including goodwill. If the carrying value of the reporting unit exceeds its fair value, the second step of the test is performed by comparing the carrying value of the goodwill in the reporting unit to its implied fair value. An impairment charge is recognized for the excess of the carrying value of goodwill over its implied fair value. For the purpose of impairment testing, we have determined that we have one reporting unit. There was no impairment of goodwill for the year ended December 31, 2019.

Our long-lived assets, excluding goodwill, consist of property and equipment and intangible assets. We periodically review our long-lived assets for impairment. For assets to be held and used, we initiate our review whenever events or changes in circumstances indicate that the carrying amount of a long-lived asset group may not be recoverable. Recoverability of an asset group is measured by comparison of its carrying amount to the expected future undiscounted cash flows that the asset group is expected to generate. If it is determined that an asset group is not recoverable, an impairment loss is recorded in the amount by which the carrying amount of the asset group exceeds its fair value. There was no impairment of long-lived assets for the year ended December 31, 2019.

Leases

We have operating leases for our administrative and sales offices, research and development laboratory and clean room. We recognize our long-term operating lease rights and commitments as operating lease right-of-use assets, operating lease liabilities and operating lease liabilities, non-current, respectively, on our 2019 Consolidated Balance Sheet.

We determine if an arrangement is, or contains, a lease at inception. Operating lease right-of-use assets, and operating lease liabilities are initially recorded based on the present value of lease payments over the lease term. Lease terms include the minimum unconditional term of the lease, and may include options to extend or terminate the lease when it is reasonably certain at the commencement date that such options will be exercised. The decision to include these options involves consideration of our overall future business plans and other relevant business economic factors that may affect our business. Since the determination of the lease term requires an application of judgment, lease terms that differ in reality from our initial judgment may potentially have a material impact on our Consolidated Balance Sheet. In addition, our leases do not provide an implicit rate. In determining the present value of our expected lease payments, the discount rate is calculated using our incremental borrowing rate determined based on the information available, which requires additional judgment.

Recent Accounting Pronouncements and Accounting Changes

See our Note 1, "Description of Business and Summary of Significant Accounting Policies" of "Notes to Consolidated Financial Statements" included under Part II, Item 8 of this Form 10-K for a description of recent accounting pronouncements and accounting changes, including the expected dates of adoption and estimated effects, if any, on our consolidated financial statements.

Results of Operations

Income Statement Presentation

In the fourth quarter of fiscal 2019, in order to improve the transparency of our revenue reporting, we updated our Consolidated Statements of Comprehensive Loss to change our historical presentation of revenue categories. Previously, we presented revenue on two lines: Solutions and Gainshare performance incentives. Included within Solutions was revenue from software and related services, and revenue from SaaS offerings, DFI™ licenses, and fixed-price project-based solution implementation services. The previous Gainshare performance incentives category included only revenue from performance incentive programs. We now present revenue in the following categories: Analytics and Integrated Yield Ramp. Integrated Yield Ramp is comprised of all revenue from our engagements that include performance incentives based on customers' yield achievement, i.e. both fixed-fees and Gainshare royalty from such engagements. Analytics comprises all other revenue, including from licenses and services for Exensio Software, Exensio SaaS, DFI and CV systems that do not contain performance incentives based on customers' yield achievement.

The change in presentation of revenue does not change our net revenues or total cost of net revenues. The following table shows reclassified amounts to conform to the current period's presentation (in thousands):

	Year Ended December 31, 2018		
	Previously Reported	Change in Presentation Reclassification	Current Presentation
Revenues:			
Design-to-silicon-yield solutions	\$ 60,081	\$ (60,081)	N/A
Gainshare performance incentives	25,713	(25,713)	N/A
Analytics	N/A	38,502	\$ 38,502
Integrated Yield Ramp	N/A	47,292	47,292
Total revenues	\$ 85,794	\$ —	\$ 85,794

Since certain costs of revenues are attributed to both Analytics and Integrated Yield Ramp revenue categories, we believe it is more appropriate and meaningful to present the Consolidated Statements of Comprehensive Loss under a one-step presentation format that excludes any measure of gross margin. In the fourth quarter of fiscal 2019, we elected to change our Consolidated Statements of Comprehensive Loss presentation from a two-step presentation, where total costs of revenues was deducted from total revenues to report a gross profit line, to a one-step presentation, where total costs and expenses are deducted from total revenues. The change in presentation does not change previously presented amounts for costs of revenues, operating expenses and other expenses (income), or loss before income taxes.

Discussion of Financial Data for the years ended December 31, 2019 and 2018

Revenues

	Year Ended December 31,		\$ Change	% Change
	2019	2018		
(Dollars in thousands)				
Revenues				
Analytics	\$ 49,627	\$ 38,502	\$ 11,125	29%
Integrated Yield Ramp	35,958	47,292	(11,334)	(24)%
Total revenues	\$ 85,585	\$ 85,794	\$ (209)	—%
Analytics revenue as a percentage of total revenues	58%	45%		
Integrated Yield Ramp revenue as a percentage of total revenues	42%	55%		

Analytics Revenue

Analytics revenue increased \$11.1 million for the year ended December 31, 2019, compared to the year ended December 31, 2018, due primarily to a \$5.9 million increase in revenue from software licenses and SaaS offerings and a \$5.2 million increase in revenue generated from DFI and CV systems due to strong business activity.

Integrated Yield Ramp Revenue

Integrated Yield Ramp revenue decreased \$11.3 million for the year ended December 31, 2019, compared to the year ended December 31, 2018, due primarily to (i) a \$9.7 million decrease in revenue from our IYR services from lower hours worked across multiple contracts and customers, and (ii) a \$1.6 million decrease in Gainshare royalty from the 28nm technology nodes, partially offset by higher incentives revenue from the 14nm technology nodes. Our Integrated Yield Ramp revenue may continue to fluctuate from period to period primarily due to the contribution of Gainshare royalty, which is dependent on many factors that are outside our control, including among others, continued production of ICs by our customers at facilities at which we generate Gainshare, sustained yield improvements by our customers, and our ability to enter into new contracts containing Gainshare.

Our revenues may fluctuate in the future and are dependent on a number of factors, including the semiconductor industry's continued acceptance of our products, services and solutions, the timing of purchases by existing and new customers, cancellations by existing customers, and our ability to attract new customers and penetrate new markets, and further penetration of our current customer base. Fluctuations in future results may also occur if any of our significant customers renegotiate pre-existing contractual commitments, including due to adverse changes in their own business.

Costs and Expenses:

Costs of Revenues

	Year Ended December 31,		\$ Change	% Change
	2019	2018		
(Dollars in thousands)				
Costs of revenues	\$ 33,474	\$ 42,803	\$ (9,329)	(22)%
<i>As a percentage of total revenues</i>	39%	50%		

Costs of revenues consist of costs incurred to provide and support our services, costs recognized in connection with licensing our software, and amortization of acquired technology. Costs of revenues consist of services costs and software licenses costs. Services costs consist of material, employee compensation and related benefits, overhead costs, travel and allocated facilities-related costs. Software license costs consist of costs associated with licensing third-party software used by the Company in providing services to our customers in solution engagements, or sold in conjunction with our software products.

The decrease in costs of revenues of \$9.3 million was primarily driven by (i) a reduction of \$9.0 million in personnel-related costs primarily relating to consulting fixed fee Integrated Yield Ramp business, which are typically labor intensive compared to software time-based license projects, and (ii) \$0.8 million decrease in travel expenses resulting from our cost management efforts, partially offset by a \$0.4 million increase in information technology-related costs and facilities expense mainly due to higher cloud-delivery related costs and depreciation expense.

Research and Development

	Year Ended December 31,		\$ Change	% Change
	2019	2018		
(Dollars in thousands)				
Research and development	\$ 32,747	\$ 27,998	\$ 4,749	17%
<i>As a percentage of total revenues</i>	38%	33%		

Research and development expenses consist primarily of personnel-related costs to support product development activities, including compensation and benefits, outside development services, travel, facilities cost allocations, and stock-based compensation charges.

Research and development expenses increased for the year ended December 31, 2019, compared to the year ended December 31, 2018, primarily due to (i) a \$4.1 million increase in personnel-related expense, driven by an increase in stock based compensation expense of \$1.5 million, higher payroll expense due to the shifting of more resources from our IYR activities to research and development activities, additional headcount, and an increase in salary expenses related to our worldwide merit increases, and (ii) a \$1.3 million increase in facilities and information technology (IT) related-costs, driven primarily by (A) higher costs allocation for certain facilities and IT related-expenses, which are calculated using a proportional allocation based on headcount, (B) an increase in development costs for cloud-based delivery for our Exensio software, (C) higher depreciation expense for our laboratory

equipment, and (D) higher amortization expense of leasehold improvements related to the expansion of our research and development laboratory and clean room. These increases in research and development expense were partially offset by a \$0.6 million decrease in subcontractor expenses primarily related to our DFI systems and Exensio software.

We anticipate our expenses in research and development will fluctuate in absolute dollars from period to period as a result of the size and the timing of product development projects and revenue generating activity requirements.

Selling, General and Administrative

	Year Ended December 31,		\$ Change	% Change
	2019	2018	2018 to 2019	
(Dollars in thousands)				
Selling, general and administrative	\$ 26,299	\$ 23,934	\$ 2,365	10%
<i>As a percentage of total revenues</i>	31%	28%		

Selling, general and administrative expenses consist primarily of compensation and benefits for sales, marketing and general and administrative personnel, legal and accounting services, marketing communications, travel and facilities cost allocations, and stock-based compensation expense.

Selling, general and administrative expenses increased for the year ended December 31, 2019, compared to the year ended December 31, 2018, primarily due to (i) a \$2.6 million increase in personnel-related expenses driven by higher payroll expenses allocated to selling and marketing activities as a result of the shifting of resources from our IYR activities, salary expenses related to our worldwide merit increases, and an increase in accrued vacation benefits, (ii) a \$0.3 million increase in other facilities and IT related-expenses, (iii) a \$0.3 million increase in legal expense, primarily related to a business acquisition in the second quarter of fiscal 2019, and (iv) a \$0.2 million increase in consulting and subcontractors fees. These increases in selling, general and administrative expenses in 2019 were partially offset by (i) a \$0.6 million decrease in professional fees due primarily to lower audit fees, (ii) a \$0.3 million decrease in travel expenses resulting from our cost management effort, and (iii) a \$0.3 million decrease in operating lease expense.

We anticipate our selling, general and administrative expenses will fluctuate in absolute dollars from period to period as a result of cost control initiatives and to support increased selling efforts in the future.

Amortization of other acquired intangible assets

	Year Ended December 31,		\$ Change	% Change
	2019	2018	2018 to 2019	
(Dollars in thousands)				
Amortization of other acquired intangible assets	\$ 609	\$ 435	\$ 174	40%

Amortization of other acquired intangible assets consists of amortization of intangibles acquired as a result of certain business combinations. The increase in amortization of other acquired intangible assets for the year ended December 31, 2019, compared to the year-ago period, was primarily related to amortization of other acquired intangible assets related to the acquisition of certain assets from StreamMosaic, Inc.

Restructuring charges

	Year Ended December 31,		\$ Change	% Change
	2019	2018	2018 to 2019	
(Dollars in thousands)				
Restructuring charges	\$ 92	\$ 576	\$ (484)	(84)%

Restructuring charges for the year ended December 31, 2019, were primarily related to employee separation charges incurred as part of our restructuring plan announced on September 27, 2018, to reduce expenses and align our operations with evolving business needs. As of December 31, 2019, we have substantially completed the implementation of the restructuring plan, and the remaining charges expected to be incurred are not expected to be significant. See Note 10, Restructuring Charges, in Notes to Consolidated Financial Statements in Item 8 of Part II of this Report for more information regarding this restructuring plan.

Interest and Other Expense (Income), Net

	Year Ended December 31,		\$ Change	% Change
	2019	2018	2018 to 2019	
(Dollars in thousands)				
Interest and other expense (income), net	\$ (276)	\$ (493)	\$ 217	44%

Interest and other expense (income), net, primarily consists of interest income and foreign currency transaction exchange gains and losses. The change in interest and other expense (income), net by \$0.2 million for the year ended December 31, 2019, compared to the year ended December 31, 2018, was primarily due to net unfavorable fluctuations in foreign exchange rates, partially offset by decrease in loss related to foreign currency forward contracts.

Income Tax Benefit

	Year Ended December 31,		\$ Change	% Change
	2019	2018	2018 to 2019	
(Dollars in thousands)				
Income tax benefit	\$ (1,942)	\$ (1,743)	\$ 199	11%

Our effective tax rate for 2019 was 26.7%, which was different from the statutory federal tax rate primarily due to impacts from employee stock-based compensation expense and tax credits. The change in income tax benefit of \$0.2 million for the year ended December 31, 2019 from an income tax provision of \$1.7 million for the year ended December 31, 2018, was primarily due to a lower unfavorable tax impact related to employee stock-based compensation expense and an increase in federal tax credits.

Any significant change in our future effective tax rates could adversely impact our consolidated financial position, results of operations and cash flows. Our future tax rates may be adversely affected by a number of factors including increase in expenses not deductible for tax purposes, tax legislations in the U.S. and in foreign countries where we are subject to tax jurisdictions, the geographic composition of our pre-tax income, the amount of our pre-tax income as business activities fluctuate, our ability to use tax attributes such as research and development tax credits and net operation losses, the tax effects of employee stock activity, audit examinations with adverse outcomes, changes in general accepted accounting principles and the effectiveness of our tax planning strategies.

For a discussion of our results of operations for the years ended December 31, 2018 and 2017, please see our Annual Report on Form 10-K for the year ended December 31, 2018 filed with the SEC on March 8, 2019.

Liquidity and Capital Resources

As of December 31, 2019, our working capital, defined as total current assets less total current liabilities, was \$119.6 million, compared to \$137.7 million as of December 31, 2018. Accounts payable was \$7.6 million as of December 31, 2019, compared to \$2.5 million as of December 31, 2018. The significant increase in accounts payable was primarily due to a vendor invoice received for a multi-year licensing and distribution agreement related to our Exensio software during the fourth quarter of fiscal 2019. Other current and non-current assets balances at December 31, 2019, also increased primarily due to the aforementioned software distribution agreement. Cash and cash equivalents, on a consolidated basis, were \$97.6 million as of December 31, 2019, compared to \$96.1 million as of December 31, 2018. As of December 31, 2019 and 2018, cash and cash equivalents held by our foreign subsidiaries were \$3.8 million and \$4.1 million, respectively. We believe that our existing cash resources and anticipated funds from operations will satisfy our cash requirements to fund our operating activities, capital expenditures, and other obligations for at least the next twelve months.

	Year Ended December 31,		\$ Change
	2019	2018	2018 to 2019
(In thousands)			
Consolidated Statements of Cash Flows Data			
Net cash flows provided by (used in):			
Operating activities	\$ 24,590	\$ 13,338	\$ 11,252
Investing activities	(13,212)	(13,116)	(96)
Financing activities	(9,835)	(5,202)	(4,633)
Effect of exchange rate changes on cash and cash equivalents	(27)	(198)	171
Net increase (decrease) in cash and cash equivalents	<u>\$ 1,516</u>	<u>\$ (5,178)</u>	<u>\$ 6,694</u>

Net Cash Provided by Operating Activities

Cash flow from operating activities during 2019 mostly consisted of net loss, adjusted for certain non-cash items, which primarily consisted of depreciation and amortization, share-based compensation expense and deferred tax assets. Cash generated from operating activities increased by \$11.3 million for the year ended December 31, 2019, compared to the year ended December 31, 2018, driven primarily by (i) a \$7.1 million increase in net change from operating assets and liabilities, (ii) a \$2.3 million decrease in net loss, and (iii) an increase in non-cash adjustments to net loss by \$1.9 million, primarily due to increases in depreciation and amortization of \$1.1 million, and increased stock-based compensation expense of \$1.1 million, partially offset by increase in deferred tax assets of \$0.4 million.

The major contributors to the net change in operating assets and liabilities for the year ended December 31, 2019, were as follows:

- Accounts receivable decreased by \$10.9 million due primarily due to collection of significant past due accounts receivables from three customers in Asia.
- Operating lease right-of-use assets and operating lease liabilities increased by \$1.4 million and \$1.3 million, respectively, as a result of the adoption of new accounting standard for leases. Refer to Note 1 of “Notes to Consolidated Financial Statements” (Item 8 of Part II of this Report) for further discussion about our adoption of Accounting Standards Update (ASU) 2016-02, Leases.
- Deferred revenues increased by \$3.4 million primarily due to timing of billing and revenue recognition.

Cash Used in Investing Activities

Cash used in investing activities was relatively flat for the year ended December 31, 2019, compared to the year-ago period.

For the year ended December 31, 2019, cash used in investing activities related to (i) \$10.6 million of property and equipment purchased primarily related to the construction of our DFI assets and expansion of our research and development laboratory and clean room, and (ii) a \$2.7 million payment for a business acquisition.

For the year ended December 31, 2018, cash used in investing activities related to property and equipment purchased for the development of our DFI system, furniture, fixtures and leasehold improvements for our new office headquarters.

Net Cash Used in Financing Activities

Net cash used in financing activities increased by \$4.6 million for the year ended December 31, 2019, compared to the year ended December 31, 2018.

For the year ended December 31, 2019, net cash used in financing activities primarily consisted of \$9.6 million cash used to repurchase shares of our common stock, and \$2.7 million cash payments for taxes related to net share settlement of equity awards, partially offset by \$2.7 million of proceeds from our Employee Stock Purchase Plan and exercise of stock options.

For the year ended December 31, 2018, net cash used in financing activities primarily consisted of \$5.2 million cash used to repurchase shares of our common stock, and \$2.1 million cash payments for taxes related to net share settlement of equity awards, partially offset by \$2.4 million of proceeds from our Employee Stock Purchase Plan and exercise of stock options.

Off-Balance Sheet Arrangements

We do not have any off-balance sheet arrangements, investments in special purpose entities or undisclosed borrowings or debt.

Contractual Obligations

The following table summarizes our known contractual obligations (in thousands) as of December 31, 2019:

Contractual Obligations	Payments Due by Period						Total
	2020	2021	2022	2023	2024	2025 and thereafter	
Operating lease obligations(1)	\$ 1,914	\$ 1,783	\$ 1,574	\$ 1,113	\$ 806	\$ 2,976	\$ 10,166
Purchase obligations(2)	11,275	2,778	1,617	363	321	321	16,675
Total(3)	\$ 13,189	\$ 4,561	\$ 3,191	\$ 1,476	\$ 1,127	\$ 3,297	\$ 26,841

- (1) Refer to Note 6 of “Notes to Consolidated Financial Statements” (Item 8 of Part II of this Report) for further discussion.
- (2) Purchase obligations consist of agreements to purchase goods and services entered in the ordinary course of business.
- (3) The contractual obligation table above excludes liabilities for uncertain tax positions of \$2.9 million, which are not practicable to assign to any particular years, due to the inherent uncertainty of the tax positions. See Note 11 of “Notes to Consolidated Financial Statements” (Item 8 of Part II of this Report) for further discussion.

Item 7A. Quantitative and Qualitative Disclosures About Market Risk

The following discusses our exposure to market risk related to changes in interest rates and foreign currency exchange rates. We do not currently own any equity investments, nor do we expect to own any in the foreseeable future. This discussion contains forward-looking statements that are subject to risks and uncertainties. Actual results could vary materially as a result of a number of factors.

Interest Rate Risk. As of December 31, 2019, we had cash and cash equivalents of \$97.6 million. Cash and cash equivalents consisted of cash and highly liquid money market instruments. We would not expect our operating results or cash flows to be affected to any significant degree by the effect of a sudden change in market interest on our portfolio. A hypothetical increase in market interest rates of 100 basis points from the market rates in effect at December 31, 2019, would cause the fair value of these investments to decrease by an immaterial amount which would not have significantly impacted our financial position or results of operations.

Foreign Currency and Exchange Risk. Certain of our payables for our international offices are denominated in the local currency, including the Euro, Yen and RMB. Therefore, a portion of our operating expenditures is subject to foreign currency risks. We enter into foreign currency forward contracts to reduce the exposure to foreign currency exchange rate fluctuations on certain foreign currency denominated monetary assets and liabilities. We do not use foreign currency forward contracts for speculative or trading purposes. We record these forward contracts at fair value. The counterparty to these foreign currency forward contracts is a financial institution that we believe is creditworthy, and therefore, we believe the credit risk of counterparty non-performance is not significant. The change in fair value of these contracts is recorded into earnings as a component of other expense (income), net and offsets the change in fair value of foreign currency denominated monetary assets and liabilities, which is also recorded in other expense (income), net. As of December 31, 2019, we had no outstanding forward contracts. Subsequent to the end of fourth fiscal quarter of 2019, we entered into one outstanding forward contract with a notional amount of \$8.4 million. A foreign currency exchange rate movement of plus-or-minus 10% will result in the change in fair value of this contract of plus-or-minus \$0.8 million.

Item 8. Financial Statements and Supplementary Data

REPORT OF INDEPENDENT REGISTERED PUBLIC ACCOUNTING FIRM

**To the Board of Directors and Stockholders
PDF Solutions, Inc.**

Opinion on the Financial Statements

We have audited the accompanying consolidated balance sheets of PDF Solutions, Inc. (a Delaware corporation) and its subsidiaries (the “Company”) as of December 31, 2019 and 2018, and the related consolidated statements of comprehensive loss, stockholders’ equity, and cash flows for each of the two years in the period ended December 31, 2019, and the related notes (collectively referred to as the “consolidated financial statements”). In our opinion, the consolidated financial statements present fairly, in all material respects, the financial position of the Company as of December 31, 2019 and 2018, and the results of its operations and its cash flows for the two years in the period ended December 31, 2019, in conformity with accounting principles generally accepted in the United States of America.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (“PCAOB”), the Company’s internal control over financial reporting as of December 31, 2019, based on criteria established in *Internal Control—Integrated Framework (2013)* issued by the Committee of Sponsoring Organizations of the Treadway Commission (COSO), and our report dated March 10, 2020, expressed an unqualified opinion.

Change in Accounting Principle

As discussed in Note 1 to the consolidated financial statements, the Company changed its method of accounting for leases in 2019 due to adoption of the new lease standard.

Basis for Opinion

These consolidated financial statements are the responsibility of the Company’s management. Our responsibility is to express an opinion on the Company’s consolidated financial statements based on our audits. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the consolidated financial statements are free of material misstatement, whether due to error or fraud. Our audits included performing procedures to assess the risks of material misstatement of the consolidated financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the consolidated financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the consolidated financial statements. We believe that our audits provide a reasonable basis for our opinion.

We have served as the Company’s auditor since 2018.

/s/ BPM LLP
San Jose, CA
March 10, 2020

REPORT OF INDEPENDENT REGISTERED PUBLIC ACCOUNTING FIRM

To the Board of Directors and Stockholders
PDF Solutions, Inc.

Opinion on Internal Control over Financial Reporting

We have audited the internal control over financial reporting of PDF Solutions, Inc. (a Delaware corporation) and its subsidiaries (the “Company”) as of December 31, 2019, based on criteria established in *Internal Control—Integrated Framework* issued by the Committee of Sponsoring Organizations of the Treadway Commission (2013 framework) (the “COSO criteria”). In our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of December 31, 2019, based on the COSO criteria.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (“PCAOB”), the consolidated balance sheets as of December 31, 2019 and 2018 and the related consolidated statements of comprehensive loss, stockholders’ equity, and cash flows for each of the two years in the period ended December 31, 2019, and the related notes (collectively referred to as the “consolidated financial statements”) of the Company, and our report dated March 10, 2020 expressed an unqualified opinion on those consolidated financial statements.

Basis for Opinion

The Company’s management is responsible for maintaining effective internal control over financial reporting, and for its assessment of the effectiveness of internal control over financial reporting, included in the accompanying Management’s Report on Assessment of Internal Controls Over Financial Reporting. Our responsibility is to express an opinion on the Company’s internal control over financial reporting based on our audit. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audit in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether effective internal control over financial reporting was maintained in all material respects. Our audit of internal control over financial reporting included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. Our audit also included performing such other procedures as we considered necessary in the circumstances. We believe that our audit provides a reasonable basis for our opinion.

Definition and Limitations of Internal Control over Financial Reporting

A company’s internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company’s internal control over financial reporting includes those policies and procedures that (1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company’s assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

/s/ BPM LLP
San Jose, California
March 10, 2020

PDF SOLUTIONS, INC.
CONSOLIDATED BALANCE SHEETS
(in thousands, except par values)

	December 31,	
	2019	2018
ASSETS		
Current assets:		
Cash and cash equivalents	\$ 97,605	\$ 96,089
Accounts receivable, net of allowances of \$213 in 2019 and \$332 in 2018	40,651	51,570
Prepaid expenses and other current assets	9,320	9,562
Total current assets	147,576	157,221
Property and equipment, net	40,798	35,681
Operating lease right-of-use assets, net	7,609	—
Goodwill	2,293	1,923
Intangible assets, net	6,221	5,064
Deferred tax assets	25,327	19,044
Other non-current assets	9,720	6,972
Total assets	<u>\$ 239,544</u>	<u>\$ 225,905</u>
LIABILITIES AND STOCKHOLDERS' EQUITY		
Current liabilities:		
Accounts payable	\$ 7,636	\$ 2,454
Accrued compensation and related benefits	5,072	4,727
Accrued and other current liabilities	1,665	3,235
Operating lease liabilities – current portion	1,867	—
Deferred revenues – current portion	10,639	8,477
Billings in excess of recognized revenues	1,117	635
Total current liabilities	27,996	19,528
Long-term income taxes payable	5,368	3,751
Non-current operating lease liabilities	7,677	—
Other non-current liabilities	2,346	2,831
Total liabilities	43,387	26,110
Commitments and contingencies (Note 7)		
Stockholders' equity:		
Preferred stock, \$0.00015 par value, 5,000 shares authorized, no shares issued and outstanding	—	—
Common stock, \$0.00015 par value, 70,000 shares authorized; shares issued 41,797 and 40,677, respectively; shares outstanding 32,503 and 32,382, respectively	\$ 5	\$ 5
Additional paid-in capital	325,197	310,660
Treasury stock, at cost, 9,294 and 8,295 shares, respectively	(91,695)	(79,142)
Accumulated deficit	(35,870)	(30,452)
Accumulated other comprehensive loss	(1,480)	(1,276)
Total stockholders' equity	196,157	199,795
Total liabilities and stockholders' equity	<u>\$ 239,544</u>	<u>\$ 225,905</u>

See accompanying notes to consolidated financial statements.

PDF SOLUTIONS, INC.
CONSOLIDATED STATEMENTS OF COMPREHENSIVE LOSS
(in thousands, except per share amounts)

	Year Ended December 31,	
	2019	2018
Revenues:		
Analytics	\$ 49,627	\$ 38,502
Integrated Yield Ramp	35,958	47,292
Total revenues	<u>85,585</u>	<u>85,794</u>
Costs and Expenses:		
Costs of revenues	33,474	42,803
Research and development	32,747	27,998
Selling, general and administrative	26,299	23,934
Amortization of other acquired intangible assets	609	435
Restructuring charges	92	576
Interest and other expense (income), net	(276)	(493)
Loss before income taxes	<u>(7,360)</u>	<u>(9,459)</u>
Income tax benefit	(1,942)	(1,743)
Net loss	<u>\$ (5,418)</u>	<u>\$ (7,716)</u>
Other comprehensive loss:		
Foreign currency translation adjustments, net of tax	(204)	(571)
Comprehensive loss	<u>\$ (5,622)</u>	<u>\$ (8,287)</u>
Net loss per share:		
Basic	<u>\$ (0.17)</u>	<u>\$ (0.24)</u>
Diluted	<u>\$ (0.17)</u>	<u>\$ (0.24)</u>
Weighted average common shares:		
Basic	<u>32,411</u>	<u>32,169</u>
Diluted	<u>32,411</u>	<u>32,169</u>

See accompanying notes to consolidated financial statements.

PDF SOLUTIONS, INC.
CONSOLIDATED STATEMENTS OF STOCKHOLDERS' EQUITY
(in thousands)

	Common Stock		Additional Paid-In Capital	Treasury Stock		Accumulated Deficit	Accumulated Other Comprehensive Loss	Total Stockholders' Equity
	Shares	Amount		Shares	Amount			
Balances, January 1, 2018	32,112	\$ 5	\$ 297,950	7,688	\$ (71,793)	\$ (27,089)	\$ (705)	\$ 198,368
Cumulative-effect adjustment from adoption of ASU 2014-09	-	-	-	-	-	4,353	-	4,353
Issuance of common stock in connection with employee stock purchase plan	201	-	1,831	-	-	-	-	1,831
Issuance of common stock in connection with exercise of options	81	-	560	-	-	-	-	560
Vesting of restricted stock units	425	-	-	-	-	-	-	-
Purchases of treasury stock in connection with tax withholdings on restricted stock grants	-	-	-	170	(2,101)	-	-	(2,101)
Repurchases of common stock	(437)	-	-	437	(5,248)	-	-	(5,248)
Stock-based compensation expense	-	-	10,319	-	-	-	-	10,319
Comprehensive loss	-	-	-	-	-	(7,716)	(571)	(8,287)
Balances, December 31, 2018	32,382	\$ 5	\$ 310,660	8,295	\$ (79,142)	\$ (30,452)	\$ (1,276)	\$ 199,795
Issuance of common stock in connection with employee stock purchase plan	172	-	1,534	-	-	-	-	1,534
Issuance of common stock in connection with exercise of options	230	-	1,289	-	-	-	-	1,289
Vesting of restricted stock units	504	-	-	-	-	-	-	-
Purchases of treasury stock in connection with tax withholdings on restricted stock grants and exercise of options	-	-	-	214	(2,786)	-	-	(2,786)
Repurchases of common stock	(785)	-	-	785	(9,767)	-	-	(9,767)
Stock-based compensation expense	-	-	11,714	-	-	-	-	11,714
Comprehensive loss	-	-	-	-	-	(5,418)	(204)	(5,622)
Balances, December 31, 2019	32,503	\$ 5	\$ 325,197	9,294	\$ (91,695)	\$ (35,870)	\$ (1,480)	\$ 196,157

See accompanying notes to consolidated financial statements.

PDF SOLUTIONS, INC.
CONSOLIDATED STATEMENTS OF CASH FLOWS
(in thousands)

	Year Ended December 31,	
	2019	2018
Cash flows from operating activities:		
Net loss	\$ (5,418)	\$ (7,716)
Adjustments to reconcile net loss to net cash provided by operating activities:		
Depreciation and amortization	6,029	4,967
Stock-based compensation expense	11,423	10,295
Amortization of acquired intangible assets	1,183	1,010
Amortization of costs capitalized to obtain revenue contracts	448	381
Adjustment to contingent consideration related to acquisition	36	114
Reversal of allowance for doubtful accounts	—	(42)
Loss on disposal and write-down in value of property and equipment	130	230
Unrealized loss on foreign currency forward contract	—	67
Deferred taxes	(4,532)	(4,171)
Changes in operating assets and liabilities:		
Accounts receivable	10,919	6,828
Prepaid expenses and other current assets	(810)	(2,496)
Operating lease right-of-use assets	1,394	—
Other non-current assets	758	3,560
Accounts payable	807	(1,406)
Accrued compensation and related benefits	261	(1,609)
Accrued and other liabilities	(597)	240
Deferred revenues	3,410	2,451
Billings in excess of recognized revenues	482	635
Operating lease liabilities	(1,333)	—
Net cash provided by operating activities	<u>24,590</u>	<u>13,338</u>
Cash flows from investing activities:		
Purchases of property and equipment	(10,552)	(13,116)
Payments of business acquisitions, net of cash acquired	(2,660)	—
Cash used in investing activities	<u>(13,212)</u>	<u>(13,116)</u>
Cash flows from financing activities:		
Payment of contingent consideration related to acquisition	(206)	(244)
Proceeds from exercise of stock options	1,161	560
Repurchases of common stock	(9,639)	(5,248)
Proceeds from employee stock purchase plan	1,534	1,831
Payments for taxes related to net share settlement of equity awards	(2,685)	(2,101)
Net cash used in financing activities	<u>(9,835)</u>	<u>(5,202)</u>
Effect of exchange rate changes on cash and cash equivalents	(27)	(198)
Net increase (decrease) in cash and cash equivalents	1,516	(5,178)
Cash and cash equivalents, beginning of year	96,089	101,267
Cash and cash equivalents, end of year	<u>\$ 97,605</u>	<u>\$ 96,089</u>
Supplemental disclosure of cash flow information:		
Cash paid during the period for:		
Taxes	\$ 2,693	\$ 2,582
Cash paid for amounts included in the measurement of operating lease liabilities	\$ 1,775	\$ —
Supplemental disclosure of noncash information:		
Stock-based compensation capitalized as software development costs	\$ 309	\$ —
Property and equipment received and accrued in accounts payable and accrued and other liabilities	\$ 1,107	\$ 2,101
Advances for purchase of fixed assets transferred from prepaid assets to property and equipment	\$ 1,416	\$ —
Operating lease liabilities arising from obtaining right-of-use assets	\$ 333	\$ —
Tenant allowance paid by landlord for leasehold improvements	\$ —	\$ 1,536
Common shares repurchased from a cashless exercise of stock options	\$ 128	\$ —

See accompanying notes to consolidated financial statements.

PDF SOLUTIONS, INC.
NOTES TO CONSOLIDATED FINANCIAL STATEMENTS

1. DESCRIPTION OF BUSINESS AND SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Description of Business

PDF Solutions, Inc. (the “Company” or “PDF”), provides differentiated data and analytics solutions to the semiconductor and electronics industries. The Company offers an end-to-end analytics platform that empowers engineers and data scientists across the semiconductor ecosystem to rapidly improve the yield, quality, and profitability of their products.

Basis of Presentation

The consolidated financial statements include the accounts of the Company and its wholly-owned subsidiaries after the elimination of all significant intercompany balances and transactions.

Reclassification of Prior Period Amount

Certain prior period amounts have been reclassified to conform to the current year presentation of reporting amortization of costs capitalized to obtain revenue contracts on the Consolidated Statements of Cash Flows. This reclassification had no effect on the Company’s reported net loss or net cash provided by operating activities.

Change in Presentation

In the fourth quarter of fiscal 2019, in order to improve the transparency of our revenue reporting, the Company updated its Consolidated Statements of Comprehensive Loss to change its historical presentation of revenue categories. Previously, the Company presented revenue on two lines: Solutions and Gainshare performance incentives. Included within Solutions, was revenue from software and related revenue, SaaS solutions, Design-for-Inspection (DFI™) licenses, and fixed-price project-based solution implementation services. The previous Gainshare performance incentive category included only revenue from performance incentive programs. The Company now presents revenue in the following categories: Analytics and Integrated Yield Ramp. Integrated Yield Ramp is comprised of all revenue from the Company’s IYR services engagements that include performance incentives based on customers’ yield achievement, i.e. both fixed-fees and Gainshare royalty from such engagements. Analytics comprises all other revenue, including from the Company’s licenses and services for Exensio Software, Exensio SaaS, DFI and CV systems that do not include performance incentives based on customers’ yield achievement.

The change in presentation of revenue does not change the Company’s net revenues or total cost of net revenues. The following table shows reclassified amounts to conform to the current period’s presentation (in thousands):

	Year Ended December 31, 2018		
	Previously Reported	Change in Presentation Reclassification	Current Presentation
Revenues:			
Design-to-silicon-yield solutions	\$ 60,081	\$ (60,081)	N/A
Gainshare performance incentives	25,713	(25,713)	N/A
Analytics	N/A	38,502	\$ 38,502
Integrated Yield Ramp	N/A	47,292	47,292
Total revenues	\$ 85,794	\$ —	\$ 85,794

Since certain costs of revenues are attributed to both Analytics and Integrated Yield Ramp revenue categories, the Company believes it is more appropriate and meaningful to present the Consolidated Statements of Comprehensive Loss under a one-step presentation format that excludes any measure of gross margin. In the fourth quarter of fiscal 2019, the Company elected to change its Consolidated Statements of Comprehensive Loss presentation from a two-step presentation, where total costs of revenues was deducted from total revenues to report a gross profit line, to a one-step presentation, where total costs and expenses are deducted from total revenues. The change in presentation does not change previously presented amounts for costs of revenues, operating expenses and other expenses (income), or loss before income taxes.

Use of Estimates

The preparation of financial statements in conformity with generally accepted accounting principles in the United States (“U.S. GAAP”) requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities, the disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Significant estimates in these financial statements include revenue recognition, stock-based compensation expense and accounting for income taxes. Actual results could differ from those estimates.

Concentration of Credit Risk

Financial instruments that potentially expose the Company to concentrations of credit risk consist primarily of cash and cash equivalents and accounts receivable. The Company maintains its cash and cash equivalents with what it considers high credit quality financial institutions.

The Company primarily sells its technologies and services to companies in Asia, Europe and North America within the semiconductor industry. As of December 31, 2019, three customers accounted for 53% of the Company’s gross accounts receivable and one customer accounted for 31% of the Company’s revenues for 2019. As of December 31, 2018, two customers accounted for 56% of the Company’s gross accounts receivable and one customer accounted for 37% of the Company’s revenues for 2018. See Note 13 for further details. The Company does not require collateral or other security to support accounts receivable. To reduce credit risk, management performs ongoing credit evaluations of its customers’ financial condition. The Company maintains allowances for potential credit losses. The allowance for doubtful accounts, which was based on management’s best estimates, could be adjusted in the near term from current estimates depending on actual experience. Such adjustments could be material to the consolidated financial statements.

Cash and Cash Equivalents

The Company considers all highly liquid investments with an original maturity of 90 days or less to be cash equivalents.

Accounts Receivable

Accounts receivable include amounts that are unbilled at the end of the period that are expected to be billed and collected within 12-month period. Unbilled accounts receivable is determined on an individual contract basis. Unbilled accounts receivable, included in accounts receivable, totaled \$7.4 million and \$22.2 million as of December 31, 2019 and 2018, respectively. Unbilled accounts receivable that are not expected to be billed and collected during the succeeding 12-month period are recorded in other non-current assets and totaled \$4.1 million and \$5.3 million as of December 31, 2019 and 2018, respectively. The Company performs ongoing credit evaluations of its customers’ financial condition. An allowance for doubtful accounts is maintained for probable credit losses based upon the Company’s assessment of the expected collectability of the accounts receivable. The allowance for doubtful accounts is reviewed on a quarterly basis to assess the adequacy of the allowance.

Allowance for doubtful accounts are summarized below (in thousands):

	Balance at Beginning of Period	Charged to Costs and Expenses	Deductions/ Write-offs of Accounts	Balance at End of Period
Allowance for doubtful accounts				
2019	\$ 332	\$ —	\$ 119	\$ 213
2018	\$ 374	\$ —	\$ 42	\$ 332

Property and Equipment

Property and equipment are stated at cost and are depreciated using the straight-line method over the estimated useful lives (in years) of the related asset as follows:

Computer equipment	3
Software	3
Furniture, fixtures, and equipment	3 - 10
Laboratory and test equipment	3 - 10
Leasehold improvements	Shorter of estimated useful life or term of lease

Long-lived Assets

The Company's long-lived assets, excluding goodwill, consist of property and equipment and intangible assets. The Company periodically reviews its long-lived assets for impairment. For assets to be held and used, the Company initiates its review whenever events or changes in circumstances indicate that the carrying amount of a long-lived asset group may not be recoverable. Recoverability of an asset group is measured by comparison of its carrying amount to the expected future undiscounted cash flows that the asset group is expected to generate. If it is determined that an asset group is not recoverable, an impairment loss is recorded in the amount by which the carrying amount of the asset group exceeds its fair value.

Goodwill

The Company records goodwill when the purchase consideration of an acquisition exceeds the fair value of the net tangible and identified intangible assets as of the date of acquisition. The Company performs an annual impairment assessment of its goodwill during the fourth quarter of each calendar year or more frequently if required to determine if any events or circumstances exist, such as an adverse change in business climate or a decline in the overall industry demand, that would indicate that it would more likely than not reduce the fair value of a reporting unit below its carrying amount, including goodwill. If events or circumstances do not indicate that the fair value of a reporting unit is below its carrying amount, goodwill is not considered to be impaired and no further testing is required. If further testing is required, the Company performs a two-step process. The first step involves comparing the fair value of its reporting unit to its carrying value, including goodwill. If the carrying value of the reporting unit exceeds its fair value, the second step of the test is performed by comparing the carrying value of the goodwill in the reporting unit to its implied fair value. An impairment charge is recognized for the excess of the carrying value of goodwill over its implied fair value. For the purpose of impairment testing, the Company has determined that it has one reporting unit. There has been no impairment of goodwill for any periods presented.

Software Development Costs

Internally developed software includes software developed to meet our internal needs to provide certain services to the customers. These capitalized costs consist of internal compensation related costs and external direct costs incurred during the application development stage and are amortized over their useful lives, generally five to six years. The costs to develop software that is marketed externally have not been capitalized as we believe our current software development process is essentially completed concurrent with the establishment of technological feasibility. As such, all related software development costs are expensed as incurred and included in research and development expense in our Consolidated Statements of Comprehensive Loss.

Research and Development

Research and development expenses consist primarily of personnel-related costs to support product development activities, including compensation and benefits, outside development services, travel, facilities cost allocations, and stock-based compensation charges. Research and development expenses are charged to operations as incurred.

Stock-Based Compensation

Stock-based compensation is estimated at the grant date based on the award's fair value and is recognized on a straight-line basis over the vesting period, generally four years. The Company has elected to use the Black-Scholes-Merton option-pricing model, which incorporates various assumptions including volatility, expected life and interest rates. The expected volatility is based on the historical volatility of the Company's common stock over the most recent period commensurate with the estimated expected life of the Company's stock options. The expected life of an award is based on historical experience and on the terms and conditions of the stock awards granted. The interest rate assumption is based upon observed Treasury yield curve rates appropriate for the expected life of the Company's stock options. As stock-based compensation expense recognized is based on awards ultimately expected to vest, it has been reduced for estimated forfeitures. Forfeitures are estimated at the time of grant and revised, if necessary, in subsequent periods if actual forfeitures differ from those estimates.

Income Taxes

The Company's provision for income tax comprises its current tax liability and change in deferred tax assets and liabilities. Deferred tax assets and liabilities are recognized for the expected tax consequences of temporary differences between the tax bases of assets and liabilities. The measurement of current and deferred tax assets and liabilities is based on provisions of enacted tax laws; the effect of future changes in tax laws or rates are not anticipated. Valuation allowances are provided to reduce deferred tax assets to an amount that in management's judgment is more likely than not to be recoverable against future taxable income. No U.S. taxes are provided on earnings of non-U.S. subsidiaries, to the extent such earnings are deemed to be permanently invested. The Company's income tax calculations are based on application of applicable U.S. federal, state or foreign tax laws. The Company's tax filings, however, are subject to audit by the respective tax authorities. Accordingly, the Company recognizes tax liabilities based upon its estimate of whether, and the extent to which, additional taxes will be due when such estimates are more-likely-than-not to be sustained. An uncertain income tax position will not be recognized if it has less than a 50% likelihood of being sustained. To the extent the final tax liabilities are different from the amounts originally accrued, the increases or decreases are recorded as income tax expense or benefit in the Consolidated Statements of Comprehensive Loss.

Net Income (Loss) Per Share

Basic net income (loss) per share is computed by dividing net income by weighted average number of common shares outstanding for the period (excluding outstanding stock options and shares subject to repurchase). Diluted net income (loss) per share is computed using the weighted-average number of common shares outstanding for the period plus the potential effect of dilutive securities which are convertible into common shares (using the treasury stock method), except in cases in which the effect would be anti-dilutive. Dilutive potential common shares consist of incremental common shares issuable upon exercise of stock options, upon vesting of restricted stock units (RSUs), contingently issuable shares for all periods and assumed issuance of shares under the Company's employee stock purchase plan. No dilutive potential common shares are included in the computation of any diluted per share amount when a loss from continuing operations was reported by the Company.

Foreign Currency Translation

The functional currency of the Company's foreign subsidiaries is the local currency for the respective subsidiary. The assets and liabilities are translated at the period-end exchange rate, and statements of comprehensive loss are translated at the average exchange rate during the year. Gains and losses resulting from foreign currency translations are included as a component of other comprehensive loss. Gains and losses resulting from foreign currency transactions are included in the Consolidated Statements of Comprehensive Loss.

Derivative Financial Instruments

The Company operates internationally and is exposed to potentially adverse movements in foreign currency exchange rates. The Company enters into foreign currency forward contracts to reduce the exposure to foreign currency exchange rate fluctuations on certain foreign currency denominated monetary assets and liabilities. The Company does not use foreign currency contracts for speculative or trading purposes. The Company records these forward contracts at fair value. The counterparty to these foreign currency forward contracts is a financial institution that the Company believes is creditworthy, and therefore, we believe the credit risk of counterparty non-performance is not significant. These foreign currency forward contracts are not designated for hedge accounting treatment. Therefore, the change in fair value of these derivatives is recorded into earnings as a component of interest and other income (expense), net and offsets the change in fair value of the foreign currency denominated monetary assets and liabilities, which are also recorded in interest and other income (expense), net. The duration of these forward contracts is usually between two to three months.

Litigation

From time to time, the Company is subject to various claims and legal proceedings that arise in the ordinary course of business. The Company accrues for losses related to litigation when a potential loss is probable and the loss can be reasonably estimated in accordance with FASB requirements. As of December 31, 2019, the Company is not a party to any material legal proceedings, thus no loss was probable and no amount was accrued.

Recently Adopted Accounting Standards

Leases

In February 2016, FASB issued Accounting Standards Update (ASU) 2016-02, Leases (Topic 842) and subsequent amendments to the initial guidance: ASU 2017-13, ASU 2018-10, ASU 2018-11, ASU 2018-20 and ASU 2019-01 (collectively, Topic 842). Topic 842 aims to increase transparency and comparability among organizations by requiring lessees to recognize leases with a term greater than 12 months as a right-of-use asset (“ROU”) and corresponding lease liabilities on the balance sheet, regardless of lease classification, and requiring disclosure of key information about leasing arrangements. The lease liability should be initially measured at the present value of the remaining contractual lease payments. Subsequently, the ROU assets will be amortized generally on a straight-line basis over the lease term, and the lease liability will bear interest expense and be reduced for lease payments. Topic 842 became effective for public companies’ financial statements issued for fiscal years beginning after December 15, 2018, including interim periods within those fiscal years. A modified retrospective application is required with an option to not restate comparative periods in the period of adoption. The Company adopted Topic 842 on January 1, 2019 using the modified retrospective approach, and financial information for the comparative period was not updated.

In addition, the Company elected the transition package of three practical expedients which allow companies not to reassess (i) whether agreements contain leases, (ii) the classification of leases, and (iii) the capitalization of initial direct costs. Further, the Company elected to not separate lease and non-lease components for all of its leases. The Company also made an accounting policy election to recognize lease expense for leases with a term of 12 months or less on a straight-line basis over the lease term and recognize no ROU or lease liability for those leases.

The Company’s lease portfolio consists primarily of real estate assets, which include administrative and sales offices, and its research and development laboratory and clean room. Some of these leases also require the Company to pay maintenance, utilities, taxes, insurance, and other operating expenses associated with the leased space. Based upon the nature of the items leased and the structure of the leases, the Company’s leases are classified as operating leases and continue to be classified as operating leases under the new accounting standard.

As a result of the adoption of the new lease accounting guidance, the Company recognized on January 1, 2019:

- operating lease liabilities of approximately \$10.5 million, which represent the present value of the remaining lease payments, as of the date of adoption, discounted using the Company’s incremental borrowing rate of 5.3%, and
- operating lease ROU assets of approximately \$8.7 million which represent the operating lease liabilities of \$10.5 million, adjusted for (1) deferred rent of approximately \$0.3 million, and (2) lease incentives or tenant improvement allowance of \$1.5 million.

The adoption of the new lease accounting standard did not have any other impact on the Company’s Consolidated Balance Sheet, and did not impact the Company’s operating results and cash flows. See Leases, in Note 6 for further information, including further discussion on the impact of adoption and changes in accounting policies relating to leases.

Income Statement – Reporting Comprehensive Income (Loss)

In February 2018, the FASB issued ASU No. 2018-02, Income Statement – Reporting Comprehensive Income (Topic 220): Reclassification of Certain Tax Effect from Accumulated Other Comprehensive Income. This update allows a reclassification from accumulated other comprehensive income to retained earnings for stranded tax effects resulting from the Tax Cuts and Job Act (TCJA) enacted in December 2017. This update became effective for the Company for fiscal years beginning after December 15, 2018 and interim periods within those fiscal years. The Company adopted this standard on January 1, 2019, and it did not have a material impact on its consolidated financial statements and footnote disclosures.

Compensation - Stock Compensation

In June 2018, the FASB issued ASU 2018-07, Compensation – Stock Compensation (Topic 718), Improvements to Nonemployee Share-Based Payment Accounting. This ASU simplifies several aspects of the accounting for nonemployee share-based payment transactions resulting from expanding the scope of Topic 718, to include share-based payment transactions for acquiring goods and services from nonemployees and making guidance consistent with the accounting for employee share-based compensation. The Company adopted this standard on January 1, 2019, and it did not have a material impact on its consolidated financial statements and footnote disclosures.

FASB Updates Certain Securities and Exchange Commission (SEC) Guidance in the Codification

In July 2019, the FASB issued ASU No. 2019-07, Codification Updates to SEC Sections – Amendments to SEC Paragraphs Pursuant to SEC Final Rule Releases No. 33-10532, “Disclosure Update and Simplification,” and Nos. 33-10231 and 33-10442, “Investment Company Reporting Modernization,” and Miscellaneous Updates. This ASU codifies the SEC releases that clarify and improve the disclosure and presentation requirements of a variety of codification topics, thereby eliminating or amending certain disclosure requirements that have become redundant, duplicative, overlapping, outdated, or superseded, in light of other SEC disclosure requirement, U.S. GAAP, or changes in the information environment. The amendments and updates to the SEC Final Rule were effective upon issuance of this ASU in July 2019. The Company adopted this ASU in the third quarter of 2019, and did not have a material impact on its consolidated financial statements and footnote disclosures. Included also in the aforementioned SEC Final Rule is extending the disclosure requirement of presenting changes in stockholders’ equity for interim periods, which became effective to and adopted by the Company in the first quarter of 2019.

Management has reviewed other recently issued accounting pronouncements and has determined there are not any that would have a material impact on the consolidated financial statements.

Recent Accounting Standards or Updates Not Yet Effective

In June 2016, the FASB issued ASU No. 2016-13, Financial Instruments – Credit Losses (Topic 326): Measurement of Credit Losses on Financial Instruments (ASU 2016-13), which requires measurement and recognition of expected credit losses for financial assets held at the reporting date based on external information, or a combination of both relating to past events, current conditions, and reasonable and supportable forecasts. ASU No. 2016-13 replaces the existing incurred loss impairment model with a forward-looking expected credit loss model which will result in earlier recognition of credit losses. Subsequent to the issuance of ASU No. 2016-13, the FASB issued ASU No. 2018-19, Codification Improvements to Topic 326, Financial Instruments – Credit Losses, ASU No. 2019-04, Codification Improvements to Topic 326, Financial Instruments – Credit Losses, Topic 815, Derivatives and Hedging, and Topic 825, Financial Instrument, ASU No. 2019-05, Financial Instruments – Credit Losses (Topic 326) Targeted Transition Relief, ASU No. 2016-13, the FASB issued ASU No. 2019-10 Financial Instruments-Credit Losses (Topic 326), Derivatives and Hedging (Topic 815), and Leases (Topic 842), and ASU No. 2019-11 Codification Improvements to Topic 326, Financial Instruments-Credit Losses. The subsequent ASUs do not change the core principle of the guidance in ASU No. 2016-13. Instead, these amendments are intended to clarify and improve operability of certain topics included within ASU No. 2016-13. Additionally, ASU No. 2019-10 defers the effective date for the adoption new standard on credit losses for public filers that are considered small reporting companies (“SRC”) as defined by the SEC to fiscal years beginning after December 15, 2022, including interim periods within those fiscal years, which will be fiscal 2023 for the Company if it continue to be classified as a SRC. The subsequent amendments will have the same effective date and transition requirements as ASU No. 2016-13. Early adoption is permitted. Topic 326 requires a modified retrospective approach by recording a cumulative-effect adjustment to retained earnings as of the beginning of the period of adoption. While the Company is currently evaluating the impact of Topic 326, the Company does not expect the adoption of this guidance to have a material impact on its consolidated financial statements and the related disclosure.

In January 2017, the FASB issued ASU No. 2017-04, Intangibles – Goodwill and Other (Topic 350). This standard eliminates step 2 from the annual goodwill impairment test. This update is effective for the Company beginning in the first quarter of 2020. Early adoption is permitted, and is to be applied on a prospective basis. The Company does not anticipate that the adoption of this ASU will have a significant impact on its consolidated financial statements or the related disclosures.

In August 2018, the FASB issued ASU No. 2018-15, Intangibles – Goodwill and Other – Internal-Use Software (Subtopic 350-40): Customer’s Accounting for Implementation Costs Incurred in a Cloud Computing Arrangement That Is a Service Contract. The new guidance clarifies the accounting for implementation costs incurred to develop or obtain internal-use software in cloud computing arrangements. Further, the standard also requires entities to expense the capitalized implementation costs of a hosting arrangement over the term of the hosting arrangement. This standard is effective for the Company beginning in the first quarter of 2020. Early adoption is permitted. ASU No. 2018-15 should be applied either retrospectively or prospectively to all implementation costs incurred after the date of adoption. The Company does not anticipate that the adoption of this ASU will have a significant impact on its consolidated financial statements or the related disclosures.

In December 2019, the FASB issued ASU No. 2019-12, Income Taxes (Topic 740) related to simplifying the accounting for income taxes. The guidance is effective for the Company beginning in the first quarter of 2021 on a prospective basis. Early adoption is permitted. The Company is currently evaluating the impact of this ASU, and does not anticipate that the adoption of this ASU will have a significant impact on its consolidated financial statements or the related disclosures.

In January 2020, the FASB issued ASU No. 2020-01-Investments-Equity Securities (Topic 321), Investments-Equity Method and Joint Ventures (Topic 323), and Derivatives and Hedging (Topic 815)-Clarifying the Interactions between Topic 321, Topic 323, and Topic 815. This ASU clarifies the interaction between accounting standards related to equity securities (ASC 321), equity method investments (ASC 323), and certain derivatives (ASC 815). The amendments in this ASU are effective for fiscal years beginning after December 15, 2020. The Company does not anticipate that the adoption of this ASU will have a significant impact on its consolidated financial statements or the related disclosures.

2. REVENUE

The Company derives revenue from two sources: Analytics revenue and Integrated Yield Ramp revenue.

The Company recognizes revenue in accordance with Financial Accounting Standards Board (“FASB”) Accounting Standard Codification (“ASC”) Topic 606, *Revenue from Contracts with Customers*, and its related amendments (collectively known as “ASC 606”). ASC 606 outlines a single comprehensive model to use in accounting for revenue arising from contracts with customers. Revenue is recognized when control of products or services is transferred to customers, in an amount that reflects the consideration the Company expects to be entitled to in exchange for those promised products or services.

The Company determines revenue recognition through the following five steps:

- Identification of the contract, or contracts, with a customer
- Identification of the performance obligations in the contract
- Determination of the transaction price
- Allocation of the transaction price to the performance obligations in the contract
- Recognition of revenue when, or as, performance obligations are satisfied

The Company accounts for a contract when it has approval and commitment from both parties, the rights of the parties are identified, payment terms are identified, the contract has commercial substance, and collectability of consideration is probable.

Contracts with multiple performance obligations

The Company enters into contracts that can include various combinations of licenses, products and services, some of which are distinct and are accounted for as separate performance obligations. For contracts with multiple performance obligations, the Company allocates the transaction price of the contract to each performance obligation on a relative basis using standalone selling price.

Analytics Revenue

Analytics revenue is derived from the following primary offerings: licenses and services for Exensio Software, Exensio SaaS, DFI and CV systems that do not include performance incentives based on customers’ yield achievement.

Revenue from standalone Exensio Software is recognized depending on whether the license is perpetual or time-based. Perpetual (one-time charge) license software is recognized at the time of the inception of the arrangement when control transfers to the customers, if the software license is distinct from the services offered by us. Revenue from post-contract support is recognized over the contract term on a straight-line basis, because we are providing (i) support and (ii) unspecified software updates on a when-and-if available basis over the contract term. Revenue from time-based-licensed software is allocated to each performance obligation and is recognized either at a point in time or over time as follows. The license component is recognized at the time of the delivery of the software license, with the post-contract support component recognized ratably over the committed term of the contract. For contracts with any combination of licenses, support, and other services, distinct performance obligations are accounted for separately. For contracts with multiple performance obligations, we allocate the transaction price of the contract to each performance obligation on a relative basis using standalone selling price (or SSP) attributed to each performance obligation.

Revenue from Exensio SaaS arrangements, which allow for the use of a cloud-based software product or service over a contractually determined period of time without taking possession of software, is accounted for as subscriptions and is recognized as revenue ratably, on a straight-line basis, over the subscription period beginning on the date the service is first made available to customers.

Revenue from DFI and CV systems that do not include performance incentives based on customers' yield achievement is recognized primarily as services are performed. Where there are distinct performance obligations, the Company allocates revenue to all deliverables based on their standalone selling prices, or SSP. In such instances, we apply judgment to estimate the range of SSPs for each performance obligation. For these contracts with multiple performance obligations, the Company allocates the transaction price of the contract to each performance obligation on a relative basis using SSP attributed to each performance obligation. Where there are not discrete performance obligations, historically, revenue is primarily recognized as services are performed using a percentage of completion method based on costs or labor-hours inputs, whichever is the most appropriate measure of the progress towards completion of the contract. Due to the nature of the work performed in these arrangements, the estimation of percentage of completion method is complex subject to many variables that require significant judgement. Key factors reviewed by us to estimate costs to complete each contract are future labor and product costs and expected productivity efficiencies. If circumstances arise that impact the original estimates of revenues, costs, or the extent of progress toward completion, revisions to the estimates are made. Revisions to estimates over the course of a service contract may be made and are accounted for on a cumulative catch-up basis. These revisions may result in increases or decreases in estimated revenues or costs. Revisions in profit estimates are reflected in the period in which the conditions that require the revisions become known and can be estimated (cumulative catch-up method). Losses on fixed-price solution implementation contracts are recognized in the period when they become probable.

Integrated Yield Ramp Revenue

The Integrated Yield Ramp revenue is derived from the Company's fixed-fee engagements that include performance incentives based on customers' yield achievement and Gainshare royalties, typically based on customer's wafer shipments, pertaining to these fixed-price contracts.

Revenue under these project-based contracts, which are delivered over a specific period of time typically for a fixed fee component paid on a set schedule, is recognized as services are performed using a percentage of completion. Similar to the services provided in connection with CV systems that are contributing to Analytics revenue, due to the nature of the work performed in these arrangements, the estimation of percentage of completion method is complex and subject to many variables that require significant judgement.

The Gainshare royalty contained in IYR contracts is a variable fee related to continued usage of the Company's IP after the fixed-fee service period ends, based on the customers' yield achievement. Revenue derived from Gainshare is contingent upon the Company's customers reaching certain defined production yield levels. Gainshare royalty periods are generally subsequent to the delivery of all contractual services and performance obligations. The Company records Gainshare as a usage-based royalty derived from customers' usage of intellectual property and records it in the same period in which the usage occurs.

Disaggregation of Revenue

The Company disaggregates revenue from contracts with customers into the timing of the transfer of goods and services and the geographical regions. The Company determined that disaggregating revenue into these categories achieves the disclosure objective to depict how the nature, amount, timing, and uncertainty of revenue and cash flows are affected by economic factors.

The Company's performance obligations are satisfied either over time or at a point-in-time. The following table represents a disaggregation of revenue by timing of revenue:

	Year Ended December 31,	
	2019	2018
Over time	66%	63%
Point-in-time	34%	37%
Total	100%	100%

International revenues accounted for approximately 58% and 60% of total revenues for the year ended December 31, 2019 and 2018, respectively. See Note 13, Customer and Geographic Information.

Significant Judgments

Judgments and estimates are required under ASC 606. Due to the complexity of certain contracts, the actual revenue recognition treatment required under ASC 606 for the Company's arrangements may be dependent on contract-specific terms and may vary in some instances.

For revenue under project-based contracts for fixed-price implementation services, revenue is recognized as services are performed using a percentage-of-completion method based on costs or labor-hours input method, whichever is the most appropriate measure of the progress towards completion of the contract. Due to the nature of the work performed in these arrangements, the estimation of percentage of completion method is complex, subject to many variables and requires significant judgment. Key factors reviewed by the Company to estimate costs to complete each contract are future labor and product costs and expected productivity efficiencies. If circumstances arise that change the original estimates of revenues, costs, or extent of progress toward completion, revisions to the estimates are made. These revisions may result in increases or decreases in estimated revenues or costs, and such revisions are reflected in revenue on a cumulative catch-up basis in the period in which the circumstances that gave rise to the revision become known.

The Company's contracts with customers often include promises to transfer products, licenses software and provide services, including professional services, technical support services, and rights to unspecified updates to a customer. Determining whether licenses and services are distinct performance obligations that should be accounted for separately, or not distinct and thus accounted for together, requires significant judgment. The Company rarely licenses software on a standalone basis, so the Company is required to estimate the range of SSPs for each performance obligation. In instances where SSP is not directly observable because the Company does not license the software or sell the service separately, the Company determines the SSP using information that may include market conditions and other observable inputs. The Company, in some cases, has more than one SSP for individual performance obligations. In these instances, the Company may use information such as the size of the customer and geographic region of the customer in determining the SSP.

The Company is required to record Gainshare royalty revenue in the same period in which the usage occurs. Because the Company generally does not receive the acknowledgment reports from its customers during a given quarter within the time frame necessary to adequately review the reports and include the actual amounts in quarterly results for such quarter, the Company accrues the related revenue based on estimates of customers underlying sales achievement. The Company's estimation process can be based on historical data, trends, seasonality, changes in the contract rate, knowledge of the changes in the industry and changes in the customer's manufacturing environment learned through discussions with customers and sales personnel. As a result of accruing revenue for the quarter based on such estimates, adjustments will be required in the following quarter to true-up revenue to the actual amounts reported.

Contract Balances

The Company performs its obligations under a contract with a customer by licensing software or providing services in exchange for consideration from the customer. The timing of the Company's performance often differs from the timing of the customer's payment, which results in the recognition of a receivable, a contract asset or a contract liability. See Note 1 for further information about accounts receivable.

The Company classifies the right to consideration in exchange for software or services transferred to a customer as either a receivable or a contract asset. A receivable is a right to consideration that is unconditional, as compared to a contract asset, which is a right to consideration that is conditional upon factors other than the passage of time. The majority of the Company's contract assets represent unbilled amounts related to fixed-price service contracts when the revenue recognized exceeds the amount billed to the customer. The contract assets are generally classified as current and are recorded on a net basis with deferred revenue (i.e. contract liabilities) at the contract level. At December 31, 2019 and 2018, contract assets of \$3.6 million and \$2.7 million, respectively, are included in prepaid expenses and other current assets in the Consolidated Balance Sheets. The Company did not record any asset impairment charges related to contract assets during fiscal year 2019 and 2018.

Deferred revenues consist substantially of amounts invoiced in advance of revenue recognition and are recognized as the revenue recognition criteria are met. Deferred revenues that will be recognized during the succeeding twelve-month period are recorded as current deferred revenues and the remaining portion is recorded as non-current deferred revenues. The non-current portion of deferred revenue included in other non-current liabilities as of December 31, 2019 and 2018 was \$2.3 million and \$1.0 million, respectively. Revenue recognized for the years ended December 31, 2019 and 2018, that was included in the deferred revenues and billings in excess of recognized revenues balances at the beginning of each reporting period was \$8.8 million and \$6.3 million, respectively.

At December 31, 2019, the aggregate amount of the transaction price allocated to the remaining performance obligations related to customer contracts that were unsatisfied or partially unsatisfied was approximately \$51.9 million. Given the applicable contract terms, the majority of this amount is expected to be recognized as revenue over the next two years, with the remainder in the following five years. This amount does not include contracts to which the customer is not committed, nor contracts for which we recognize revenue equal to the amount we have the right to invoice for services performed, or future sales-based or usage-based royalty payments in exchange for a license of intellectual property. This amount is subject to change due to future revaluations of variable consideration, terminations, other contract modifications, or currency adjustments. The estimated timing of the recognition of remaining unsatisfied performance obligations is subject to change and is affected by changes to the scope, change in timing of delivery of products and services, or contract modifications.

The adjustment to revenue recognized in the years ended December 31, 2019 and 2018 from performance obligations satisfied (or partially satisfied) in previous periods was an increase of \$3.2 million and \$1.8 million, respectively. These amounts primarily represent changes in estimated percentage-of-completion based contracts and changes in estimated Gainshare royalty for those customers that reported actual Gainshare revenue with some time lag.

Costs to obtain or fulfill a contract

The Company capitalizes the incremental costs to obtain or fulfill a contract with a customer, including direct sales commissions and related fees, when it expects to recover those costs. Amortization expense related to these capitalized costs is recognized over the period associated with the revenue from which the cost was incurred. Total capitalized direct sales commission costs included in prepaid expenses and other current assets in the accompanying Consolidated Balance Sheets as of December 31, 2019 and 2018 was \$0.4 million. Total capitalized direct sales commission costs included in other non-current assets in the accompanying Consolidated Balance Sheets was \$0.4 million as of December 31, 2019 and the amount was immaterial as of December 31, 2018. Amortization of these assets for each of the years ended December 31, 2019 and 2018 was \$0.4 million. There was no impairment loss in relation to the costs capitalized for the periods presented.

Certain eligible initial project costs are capitalized when the costs relate directly to the contract, the costs generate or enhance resources of the Company that will be used in satisfying the performance obligation in the future, and the costs are expected to be recovered. These costs primarily consist of transition and set-up costs related to the installation of systems and processes and other deferred fulfillment costs eligible for capitalization. Capitalized costs are amortized consistent with the transfer to the customer of the services to which the asset relates and recorded as a component of cost of revenues. The Company also incurs certain direct costs to provide services in relation to the specific anticipated contracts. The Company recognizes such costs as a component of cost of revenues, the timing of which is dependent upon identification of a contract arrangement. The Company also defers costs from

arrangements that required it to defer the revenues, typically due to the pattern of transfer of the performance obligations in the contract. These costs are recognized in proportion to the related revenue. At the end of the reporting period, the Company evaluates its deferred costs for their probable recoverability. The Company recognizes impairment of deferred costs when it is determined that the costs no longer have future benefits and are no longer recoverable. There was no impairment loss in relation to the costs capitalized for the periods presented. Deferred costs balance included in prepaid expenses and other current assets in the accompanying Consolidated Balance Sheets as of December 31, 2019 and 2018 was \$0.3 million and \$0.2 million respectively. Deferred costs balance included in other non-current assets in the accompanying Consolidated Balance Sheets was \$0.2 million as of December 31, 2019 and the amount was immaterial as of December 31, 2018.

Practical Expedients

The Company does not adjust transaction price for the effects of a significant financing component when the period between the transfers of the promised good or service to the customer and payment for that good or service by the customer is expected to be one year or less. The Company assessed each of its revenue generating arrangements in order to determine whether a significant financing component exists, and determined its contracts did not include a significant financing component for the years ended December 31, 2019 and 2018.

3. PROPERTY AND EQUIPMENT

Property and equipment consist of (in thousands):

	December 31,	
	2019	2018
Computer equipment	\$ 10,880	\$ 10,536
Software	4,690	4,112
Furniture, fixtures, and equipment	2,395	2,299
Leasehold improvements	6,095	5,474
Laboratory and other equipment	4,933	2,389
Test equipment	22,980	14,697
Construction-in-progress	18,245	20,293
	70,218	59,800
Less: accumulated depreciation and amortization	(29,420)	(24,119)
Total	<u>\$ 40,798</u>	<u>\$ 35,681</u>

Test equipment includes DFI™ assets at customer sites that are contributing to DFI™ revenues. The construction-in-progress balance related to construction of DFI™ assets totaled \$16.6 million and \$17.4 million as of December 31, 2019 and 2018, respectively. Depreciation and amortization expense for years ended December 31, 2019 and 2018 was \$6.0 million and \$5.0 million, respectively.

4. BUSINESS COMBINATION

On April 29, 2019 (the “Acquisition Date”), the Company acquired certain assets from StreamMosaic, Inc., a privately held provider of artificial intelligence and machine learning solutions, including the Stream.AI software product line and related assets. Pursuant to the terms of an asset purchase agreement, the Company acquired certain assets, including all intellectual property, from StreamMosaic and certain related liabilities for the purpose of enhancing the Company’s position in advanced data analytics for semiconductors and electronics by broadening its product offering and expanding its customer reach. In connection with the acquisition, the Company paid a total consideration of approximately \$2.7 million using cash on hand.

The Company accounted for this acquisition as a business combination. This method requires that assets acquired and liabilities assumed in a business combination be recognized at their fair values as of the Acquisition Date. The excess of purchase consideration over the fair value of net tangible and identifiable intangible assets acquired was recorded as goodwill. The goodwill recorded from this acquisition represents business benefits the Company anticipates from the acquired workforce and expectation for expanded sales opportunities in advanced data analytics for semiconductors and electronics. The amount of goodwill expected to be deductible for tax purposes is \$370,000. Pro-forma results of operations have not been presented because the effect of the acquisition was not material to our financial results.

Intangible assets consist of developed technology and customer relationships. The value assigned to intangibles are based on estimates and judgments regarding expectations for success and life cycle of intangibles acquired. The following table summarizes the allocation of the fair values of the assets acquired and liabilities assumed and the related useful lives, where applicable:

	(in thousands)	Amortization period (years)
Finite-lived intangible assets:		
Developed technology	\$ 1,640	9
Customer relationship	700	9
Deferred revenue	(50)	
Net asset acquired	\$ 2,290	
Goodwill	370	
Purchase consideration	\$ 2,660	

5. GOODWILL AND INTANGIBLE ASSETS

As of December 31, 2019 and 2018, the carrying amounts of goodwill were \$2.3 million and \$1.9 million, respectively.

Intangible assets balance was \$6.2 million and \$5.1 million as of December 31, 2019 and 2018, respectively. Intangible assets as of December 31, 2019 and 2018, consist of the following (in thousands):

(Dollars in thousands)	Amortization Period (Years)	December 31, 2019			December 31, 2018		
		Gross Carrying Amount	Accumulated Amortization	Net Carrying Amount	Gross Carrying Amount	Accumulated Amortization	Net Carrying Amount
Customer relationships	1 - 9	\$ 7,440	\$ (4,935)	\$ 2,505	\$ 6,740	\$ (4,514)	\$ 2,226
Developed technology	4 - 9	17,460	(14,101)	3,359	15,820	(13,404)	2,416
Tradename	2 - 7	790	(673)	117	790	(648)	142
Patent	7 - 10	1,800	(1,560)	240	1,800	(1,520)	280
Total		\$ 27,490	\$ (21,269)	\$ 6,221	\$ 25,150	\$ (20,086)	\$ 5,064

The weighted average amortization period for acquired identifiable intangible assets was 6.2 years as of December 31, 2019. Intangible asset amortization expense for years ended December 31, 2019 and 2018 was \$1.2 million and \$1.0 million, respectively. The Company expects annual amortization of acquired identifiable intangible assets to be as follows (in thousands):

Year Ending December 31,	
2020	\$ 1,269
2021	1,093
2022	886
2023	886
2024	747
2025 and thereafter	1,340
Total future amortization expense	\$ 6,221

Intangible assets are amortized over their useful lives unless these lives are determined to be indefinite. Intangible assets are reviewed for impairment whenever events or changes in circumstances indicate that the carrying amount of an asset or asset group may not be recoverable. During year ended December 31, 2019, there were no indicators of impairment related to the Company's intangible assets.

6. LEASES

The Company leases administrative and sales offices under noncancelable operating leases, which contain various renewal options and, in some cases, require payment of common area costs, taxes, and utilities. These operating leases expire at various times through 2028. The Company had no leases that were classified as a financing lease as of December 31, 2019.

Leases with an initial term of 12 months or less are not recorded on the Consolidated Balance Sheet and the Company recognizes lease expense for these leases on a straight-line basis over the lease term. Long-term operating leases are included in operating lease ROU assets and operating lease liabilities in the Company's Consolidated Balance Sheet as of December 31, 2019.

ROU assets represent the Company's right to use an underlying asset for the lease term and operating lease liabilities represent the Company's obligation to make lease payments arising from the lease. Effective January 1, 2019, operating lease ROU assets and liabilities are recognized based on the present value of remaining lease payments over the lease term. In determining the present value of lease payments, implicit rate must be used when readily determinable. As the Company's leases do not provide implicit rates, at the date of the Company's adoption of the new lease standard, the discount rate is calculated using the Company's incremental borrowing rate determined based on the information available. The operating lease ROU asset also includes any lease payments made and excludes lease incentives or tenant improvement allowance. The Company's lease terms may include options to extend or terminate the lease when it is reasonably certain that the Company will exercise that option. Lease expense for lease payments is recognized on a straight-line basis over the lease term.

Operating lease expense for years ended December 31, 2019 and 2018 was \$2.3 million and \$2.5 million, respectively. For the year ended December 31, 2019, operating lease cost includes short-term leases of approximately \$0.2 million and variable lease costs of \$0.3 million.

Maturity of operating lease liabilities as of December 31, 2019, are as follows (in thousands):

Year ending December 31,	Amount(1)
2020	\$ 1,914
2021	1,783
2022	1,574
2023	1,355
2024	1,070
2025 and thereafter	3,789
Total future minimum lease payments	\$ 11,485
Less: Interest(2)	(1,941)
Present value of operating lease liabilities(3)	\$ 9,544

(1) As of December 31, 2019, the total operating lease liability includes \$1.0 million related to an option to extend a lease term that is reasonably certain to be exercised.

(2) Calculated using incremental borrowing interest rate for each lease.

(3) Includes the current portion of operating lease liabilities of \$1.9 million as of December 31, 2019.

As of December 31, 2019, the weighted average remaining lease term under operating ROU leases was 7.2 years.

As of December 31, 2019, the weighted average discount rate for operating lease liabilities was approximately 5.25%.

ROU assets obtained in exchange for operating lease liabilities during the year ended December 31, 2019 were approximately \$0.3 million.

7. COMMITMENTS AND CONTINGENCIES

Indemnifications

The Company generally provides a warranty to its customers that its software will perform substantially in accordance with documented specifications typically for a period of 90 days following delivery of its products. The Company also indemnifies certain customers from third-party claims of intellectual property infringement relating to the use of its products. Historically, costs related to these guarantees have not been significant. The Company is unable to estimate the maximum potential impact of these guarantees on its future results of operations.

Purchase obligations

The Company has purchase obligations with certain suppliers for the purchase of goods and services entered in the ordinary course of business. As of December 31, 2019, total outstanding purchase obligations were \$16.7 million, the majority of which due within the next 24 months.

Indemnification of Officers and Directors

As permitted by the Delaware general corporation law, the Company has included a provision in its certificate of incorporation to eliminate the personal liability of its officers and directors for monetary damages for breach or alleged breach of their fiduciary duties as officers or directors, other than in cases of fraud or other willful misconduct.

In addition, the Bylaws of the Company provide that the Company is required to indemnify its officers and directors even when indemnification would otherwise be discretionary, and the Company is required to advance expenses to its officers and directors as incurred in connection with proceedings against them for which they may be indemnified. The Company has entered into indemnification agreements with its officers and directors containing provisions that are in some respects broader than the specific indemnification provisions contained in the Delaware general corporation law. The indemnification agreements require the Company to indemnify its officers and directors against liabilities that may arise by reason of their status or service as officers and directors other than for liabilities arising from willful misconduct of a culpable nature, to advance their expenses incurred as a result of any proceeding against them as to which they could be indemnified, and to obtain directors' and officers' insurance if available on reasonable terms. The Company has obtained directors' and officers' liability insurance in amounts comparable to other companies of the Company's size and in the Company's industry. Since a maximum obligation of the Company is not explicitly stated in the Company's Bylaws or in its indemnification agreements and will depend on the facts and circumstances that arise out of any future claims, the overall maximum amount of the obligations cannot be reasonably estimated.

Litigation

From time to time, the Company is subject to various claims and legal proceedings that arise in the ordinary course of business. The Company accrues for losses related to litigation when a potential loss is probable and the loss can be reasonably estimated in accordance with FASB requirements. As of December 31, 2019, the Company was not party to any material legal proceedings, thus no loss was probable and no amount was accrued.

8. STOCKHOLDERS' EQUITY

Stock Repurchase Program

On October 25, 2016, the Board of Directors adopted a program (the "2016 Program") that was effective immediately to repurchase up to \$25.0 million of the Company's common stock both on the open market and in privately negotiated transactions over the next two years. On May 29, 2018, the Board of Directors terminated the 2016 stock repurchase program, and adopted a new program ("2018 Program") to repurchase up to \$25.0 million of the Company's common stock both on the open market and in privately negotiated transactions over the next two years. During the year ended and as of December 31, 2019, the Company repurchased approximately 785,000 shares at an average price of \$12.43 per share, for a total price of \$9.8 million, under the 2018 Program. During the year ended December 31, 2018, the Company repurchased 437,000 shares at an average price of \$12.01 per share, for a total price of \$5.2 million under the 2016 program and no shares were repurchased under the 2018 program. As of May 29, 2018, the Company had repurchased approximately 1,279,000 shares at an average price of \$14.59 per share, for a total price of \$18.7 million, under the 2016 Program. Under the 2018 program, as of December 31, 2019, \$15.2 million of the Company's common stock remained available for future repurchases.

9. EMPLOYEE BENEFIT PLANS

Employee Stock Purchase Plan

In July 2001, the Company adopted a ten-year Employee Stock Purchase Plan (as amended, the “Purchase Plan”) under which eligible employees can contribute up to 10% of their compensation, as defined in the Purchase Plan, towards the purchase of shares of PDF common stock at a price of 85% of the lower of the fair market value at the beginning of the offering period or the end of the purchase period. The Purchase Plan consists of twenty-four-month offering periods with four six-month purchase periods in each offering period. Under the Purchase Plan, on January 1 of each year, starting with 2002, the number of shares reserved for issuance will automatically increase by the lesser of (1) 675,000 shares, (2) 2% of the Company’s outstanding common stock on the last day of the immediately preceding year, or (3) the number of shares determined by the board of directors. At the annual meeting of stockholders on May 18, 2010, the Company’s stockholders approved an amendment to the Purchase Plan to extend it through May 17, 2020. As of December 31, 2019, 9,381,000 shares of the Company’s common stock have been reserved for issuance under the Purchase Plan. During 2019 and 2018, the number of shares issued were 172,000 and 201,000, respectively, at a weighted average price of \$8.92 and \$9.12 per share, respectively. As of December 31, 2019, 5.2 million shares were available for future issuance under the Purchase Plan. The weighted average estimated fair value of shares granted under the Purchase Plan during 2019 and 2018 was \$3.72 and \$3.62, respectively. As of December 31, 2019, there was \$0.8 million of unrecognized compensation cost related to the Purchase Plan. That cost is expected to be recognized over a weighted average period of 1.13 years.

Stock Incentive Plans

On November 16, 2011, the Company’s stockholders initially approved the 2011 Stock Incentive Plan, which has been amended and restated and approved by the Company’s stockholders a number of times since then (as amended, the “2011 Plan”). Under the 2011 Plan, the Company may award stock options, stock appreciation rights, stock grants or stock units covering shares of the Company’s common stock to employees, directors, non-employee directors and contractors. The aggregate number of shares reserved for awards under this plan is 10,300,000 shares, plus up to 3,500,000 shares previously issued under the 2001 Stock Plan adopted by the Company in 2001, which expired in 2011 (the “2001 Plan”) that are (i) forfeited or (ii) repurchased by the Company or shares subject to awards previously issued under the 2001 Plan that expire or that terminate without having been exercised or settled in full on or after November 16, 2011. In case of awards other than options or stock appreciation rights (SARs), the aggregate number of shares reserved under the 2011 Plan will be decreased at a rate of 1.33 shares issued pursuant to such awards. The exercise price for stock options must generally be at prices no less than the fair market value at the date of grant. Stock options generally expire ten years from the date of grant and become vested and exercisable over a four-year period.

In 2003, in connection with its acquisition of IDS Systems Inc., the Company assumed IDS’ 2001 Stock Option / Stock Issuance Plan (the “IDS Plan”). The IDS Plan expired in 2011. Stock options granted under the 2001 and IDS Plans generally expire ten years from the date of grant and become vested and exercisable over a four-year period. Although no new awards may be granted under the 2001 or IDS Plans, awards made under the 2001 and IDS Plans that are currently outstanding remain subject to the terms of each such plan.

As of December 31, 2019, 10.8 million shares of common stock were reserved to cover stock-based awards under the 2011 Plan, of which 3.5 million shares were available for future grant. The number of shares reserved and available under the 2011 Plan includes 0.5 million shares that were subject to awards previously made under the 2001 Plan and were forfeited, expired or repurchased by the Company after adoption of the 2011 Plan through December 31, 2019. As of December 31, 2019, there were no outstanding awards that had been granted outside of the 2011, 2001 or the IDS Plans (collectively, the “Stock Plans”).

The Company has elected to use the Black-Scholes-Merton option-pricing model, which incorporates various assumptions including volatility, expected life, interest rate and expected dividend. The expected volatility is based on the historical volatility of the Company’s common stock over the most recent period commensurate with the estimated expected life of the Company’s stock options. The expected life of an award is based on historical experience and on the terms and conditions of the stock awards granted to employees. The interest rate assumption is based upon observed Treasury yield curve rates appropriate for the expected life of the Company’s stock options.

The fair value of equity awards granted was estimated on the date of grant with the following weighted average assumptions:

	Stock Plans		Employee Stock Purchase Plan	
	2019	2018	2019	2018
Expected life (in years)	4.46	4.43	1.25	1.25
Volatility	41.56%	43.91%	44.85%	42.85%
Risk-free interest rate	1.86%	2.73%	2.49%	2.48%
Expected dividend	—	—	—	—

Stock-based compensation is estimated at the grant date based on the award's fair value and is recognized on a straight-line basis over the vesting periods, generally four years. As stock-based compensation expense recognized is based on awards ultimately expected to vest, it has been reduced for estimated forfeitures. Forfeitures are estimated at the time of grant and revised, if necessary, in subsequent periods if actual forfeitures differ from those estimates.

Stock-based compensation expenses related to the Company's stock plans and employee stock purchase plan were allocated as follows (in thousands):

	Year Ended December 31,	
	2019	2018
Costs of revenues	\$ 3,185	\$ 3,554
Research and development	4,764	3,260
Selling, general and administrative	3,474	3,481
Stock-based compensation expenses	\$ 11,423	\$ 10,295

The stock-based compensation expense in the table above includes immaterial expense or credit adjustments related to cash-settled SARs granted to certain employees. The Company accounted for these awards as liability awards and the amount was included in accrued compensation and related benefits. Stock-based compensation capitalized in the capitalized software development costs included in the Property and Equipment, net, was approximately \$0.3 million at December 31, 2019.

Additional information with respect to options under the Plans is as follows:

	Outstanding Options		Weighted Average Remaining Contractual Term (Years)	Aggregate Intrinsic Value (in thousands)
	Number of Options (in thousands)	Weighted Average Exercise Price per Share		
Outstanding, January 1, 2018	1,045	\$ 9.65		
Granted (weighted average fair value of \$4.08 per share)	116	\$ 10.35		
Exercised	(81)	\$ 6.93		
Canceled	(30)	\$ 13.41		
Expired	(23)	\$ 13.16		
Outstanding, December 31, 2018	1,027	\$ 9.75		
Granted (weighted average fair value of \$5.00 per share)	102	\$ 13.79		
Exercised	(238)	\$ 5.41		
Canceled	(87)	\$ 14.57		
Expired	(59)	\$ 15.83		
Outstanding, December 31, 2019	745	\$ 10.64	4.49	\$ 4,777
Vested and expected to vest, December 31, 2019	731	\$ 10.59	4.40	\$ 4,722
Exercisable, December 31, 2019	571	\$ 9.92	3.21	\$ 4,090

The aggregate intrinsic value in the table above represents the total intrinsic value based on the Company's closing stock price of \$16.89 as of December 31, 2019, which would have been received by the option holders had all option holders exercised their options as of that date. The total intrinsic value of options exercised during the years ended December 31, 2019 and 2018 was \$1.7 million and \$0.4 million, respectively.

As of December 31, 2019, there was \$0.7 million of total unrecognized compensation cost, net of forfeitures, related to unvested stock options. That cost is expected to be recognized over a weighted average period of 2.8 years. The total fair value of options vested during the year ended December 31, 2019, was \$0.3 million.

Nonvested shares (restricted stock units) were as follows:

	Shares (in thousands)	Fair Value
Nonvested, January 1, 2018	1,617	\$ 15.66
Granted	983	\$ 8.66
Vested	(596)	\$ 15.84
Forfeited	(169)	\$ 14.83
Nonvested, December 31, 2018	1,835	\$ 11.93
Granted	952	\$ 13.52
Vested	(710)	\$ 13.05
Forfeited	(190)	\$ 12.18
Nonvested, December 31, 2019	1,887	\$ 12.30

As of December 31, 2019, there was \$17.7 million of total unrecognized compensation cost related to restricted stock units. That cost is expected to be recognized over a weighted average period of 2.6 years. Restricted stock units do not have rights to dividends prior to vesting.

401(k) Savings Plan

In 1999, the Company established a 401(k) tax-deferred savings plan, whereby eligible employees may elect to defer up to 60% of their eligible compensation but not to exceed the statutorily prescribed limit to the 401(k) plan. The 401(k) plan also has a catch-up contribution feature for employees aged 50 or older who can defer up to 100% of their eligible compensation but not to exceed the statutorily prescribed limit to the 401(k) plan. Company contributions to this plan are discretionary; no such Company contributions have been made since the inception of this plan.

10. RESTRUCTURING CHARGES

On September 27, 2018, the Board of Directors of the Company approved a reduction in its workforce to reduce expenses and align its operations with evolving business needs. Notifications to the affected employees began on October 24, 2018.

From inception of the restructuring plan to December 31, 2019, the Company has recorded restructuring charges of \$0.7 million, primarily consisting of employee separation charges. As of December 31, 2019, the Company has substantially completed the implementation of the restructuring plan, and the remaining charges expected to be incurred are not expected to be significant.

The following table summarizes the activities of restructuring liabilities under this plan (in thousands):

	Year Ended December 31,	
	2019	2018
Beginning balance	\$ 244	\$ —
Restructuring charges	92	576
Cash payments	(336)	(332)
Ending balance	\$ —	\$ 244

11. INCOME TAXES

The Company has not provided for any foreign withholding tax for any undistributed earnings for its foreign subsidiaries as of December 31, 2019. The Company intends to permanently reinvest the foreign earnings outside of the U.S.

	Year Ended December 31,	
	2019	2018
(In thousands)		
U.S.		
Current	\$ (107)	\$ (84)
Deferred	(4,534)	(4,171)
Foreign		
Current	312	347
Withholding	2,385	2,165
Deferred	2	—
Total income tax benefit	<u>\$ (1,942)</u>	<u>\$ (1,743)</u>

During the years ended December 31, 2019 and 2018, loss before taxes from U.S. operations was (\$8.7) million and (\$11.1) million, respectively, and income before taxes from foreign operations was \$1.3 million and \$1.6 million, respectively.

The income tax benefit differs from the amount estimated by applying the statutory federal income tax rate (21% for 2019 and 2018) for the following reasons (in thousands):

	Year Ended December 31,	
	2019	2018
Federal statutory tax provision	\$ (1,546)	\$ (1,986)
State tax provision	(85)	(133)
Stock compensation expense	234	768
Tax credits	(2,974)	(2,682)
Foreign tax, net	2,430	2,104
Other	(1)	186
Total income tax benefit	<u>\$ (1,942)</u>	<u>\$ (1,743)</u>

As of December 31, 2019, the Company had Federal and California net operating loss carry-forwards (“NOLs”) of approximately \$18.0 million and \$6.3 million, respectively. Some of the Federal NOLs, acquired as part of Synticity acquisition, will expire at the end of 2020 and onwards, and the California NOLs begin expiring in 2028 onwards.

As of December 31, 2019, the Company had federal and state research and experimental and other tax credit (“R&D credits”) carry-forwards of approximately \$14.3 million and \$18.9 million, respectively. The federal credits begin to expire after 2025, while the California credits have no expiration. The extent to which the federal and state credit carry forwards can be used to offset future tax liabilities, respectively, may be limited, depending on the extent of ownership changes within any three-year period as provided in the Tax Reform Act of 1986 and the California Conformity Act of 1987.

The Company assesses its deferred tax assets for recoverability on a regular basis, and where applicable, a valuation allowance is recorded to reduce the total deferred tax asset to an amount that will, more likely than not, be realized in the future. As of December 31, 2019 and 2018, the Company believes that most of its deferred tax assets are “more-likely-than not” to be realized with the exception of California R&D tax credits that have not met the “more-likely-than not” realization threshold criteria because on an annual basis and pursuant to current law, the Company generates more California credits than California tax. As a result, at December 31, 2019 and 2018, the excess credits of \$10.4 million and \$9.7 million, respectively continued to be subject to a full valuation allowance. In addition, the Company had approximately \$0.1 million of California NOL carryforward from its acquisition of Synticity. The Company evaluated positive and negative evidence and concluded that it was more likely than not that the California NOL would not be fully realizable. As a result of management’s evaluation, the Company recorded full valuation allowance against its deferred tax assets related to its California NOL. The Company will continue to review its deferred tax assets in accordance with the applicable accounting standards. Net deferred tax assets balance as of December 31, 2019 and 2018 was \$22.9 million and \$18.3 million, respectively.

The components of the net deferred tax assets are comprised of (in thousands):

	December 31,	
	2019	2018
Deferred tax assets		
Net operating loss carry forward	\$ 4,596	\$ 2,720
Research and development and other credit carry forward	18,944	17,750
Foreign tax credit carry forward	6,443	3,994
Accruals deductible in different periods	1,968	2,198
Leases	1,850	—
Intangible assets	741	1,081
Stock-based compensation	1,271	1,109
Total deferred tax assets	35,813	28,852
Less: valuation allowance	(10,486)	(9,808)
Deferred tax assets, net of valuation allowance	\$ 25,327	\$ 19,044
Deferred tax liabilities		
Property and equipment, net	(611)	(710)
Operating lease right-of-use assets	(1,850)	—
Deferred tax liabilities	\$ (2,461)	\$ (710)
Net deferred tax assets	\$ 22,866	\$ 18,334

In accordance with the accounting standard relating to accounting for uncertain tax positions, the Company classifies its liabilities for income tax exposures as long-term. The Company includes interest and penalties related to unrecognized tax benefits within the Company's income tax provision. As of December 31, 2019 and 2018, the Company had accrued interest and penalties related to unrecognized tax benefits of \$0.8 million. In the years ended December 31, 2019 and 2018, the Company recognized charges for (reversal of) interest and penalties related to unrecognized tax benefits of (\$1,000) and \$84,000, respectively, in the Consolidated Statements Comprehensive Loss.

The Company's total amount of unrecognized tax benefits, excluding interest and penalties, as of December 31, 2019 was \$13.6 million, of which \$7.9 million, if recognized, would impact the Company's effective tax rate. As of December 31, 2019, the Company has recorded unrecognized tax benefits of \$2.9 million, including interest and penalties of \$0.8 million, as long-term income taxes payable in its Consolidated Balance Sheet. The remaining \$11.5 million has been recorded net of our deferred tax assets, of which \$5.8 million is subject to a full valuation allowance. The Company does not expect the change in unrecognized tax benefits over the next twelve months to materially impact its results of operations and financial position.

The Company conducts business globally and, as a result, files numerous consolidated and separate income tax returns in the U.S. federal, various state and foreign jurisdictions. Because the Company used some of the tax attributes carried forward from previous years to tax years that are still open for audit, the federal and California statute of limitations remains open for all tax years since 1999 and 2002, respectively. The Company is not subject to income tax examinations in any other of its major foreign subsidiaries' jurisdictions.

A reconciliation of the beginning and ending amount of unrecognized tax benefits is as follows (in thousands):

	Amount
Gross unrecognized tax benefits, January 1, 2018	\$ 12,889
Increases in tax positions for current year	664
Increases in tax positions for prior years	—
Lapse in statute of limitations	(261)
Gross unrecognized tax benefits, December 31, 2018	13,292
Increases in tax positions for current year	667
Increases in tax positions for prior years	1
Lapse in statute of limitations	(345)
Gross unrecognized tax benefits, December 31, 2019	\$ 13,615

We do not provide deferred taxes on undistributed earnings of our foreign subsidiaries as we intend to indefinitely reinvest those earnings.

Valuation allowance for deferred tax assets is summarized (in thousands):

	Balance at Beginning of Period	Charged to Costs and Expenses	Deductions/ Write-offs of Accounts	Balance at End of Period
Valuation allowance for deferred tax assets				
2019	\$ 9,808	\$ 678	\$ —	\$ 10,486
2018	\$ 9,126	\$ 682	\$ —	\$ 9,808

12. NET LOSS PER SHARE

Basic net loss per share is computed by dividing net loss by weighted average number of common shares outstanding for the period (excluding outstanding stock options and shares subject to repurchase). Diluted net loss per share is computed using the weighted-average number of common shares outstanding for the period plus the potential effect of dilutive securities which are convertible into common shares (using the treasury stock method), except in cases in which the effect would be anti-dilutive. The following is a reconciliation of the numerators and denominators used in computing basic and diluted net loss per share (in thousands except per share amount):

	Year Ended December 31,	
	2019	2018
Numerator:		
Net loss	\$ (5,418)	\$ (7,716)
Denominator:		
Basic weighted-average shares outstanding	32,411	32,169
Effect of dilutive options and restricted stock units	—	—
Diluted weighted-average shares outstanding	32,411	32,169
Net loss per share – Basic	\$ (0.17)	\$ (0.24)
Net loss per share – Diluted	\$ (0.17)	\$ (0.24)

For the years ended December 31, 2019 and 2018, because the Company was in a loss position, basic net loss per share is the same as diluted net loss per share as the inclusion of the potential common shares would have been anti-dilutive.

The following table sets forth potential shares of common stock that are not included in the diluted net loss per share calculation above because to do so would be anti-dilutive for the periods indicated (in thousands):

	Year Ended December 31,	
	2019	2018
Outstanding options	538	669
Nonvested shares of restricted stock units	915	1,060
Employee Stock Purchase Plan	141	237
Total	1,594	1,966

13. CUSTOMER AND GEOGRAPHIC INFORMATION

Operating segments are defined as components of an enterprise about which separate financial information is available that is evaluated regularly by the chief operating decision maker, or group, in deciding how to allocate resources and in assessing performance.

The Company's chief operating decision maker, the chief executive officer, reviews discrete financial information presented on a consolidated basis for purposes of regularly making operating decisions, allocation of resources, and assessing financial performance. Accordingly the Company considers itself to be in one operating and reporting segment, specifically the provision of services for differentiated data and analytics solutions to the semiconductor and electronics industries.

The Company had revenues from a customer in excess of 10% of total revenues as follows:

Customer	Year Ended December 31,	
	2019	2018
A	31%	37%

The Company had accounts receivable balances (including amounts that are unbilled) from individual customers in excess of 10% of the gross accounts receivable balance as follows:

Customer	December 31,	
	2019	2018
A	27%	35%
B	14%	9%
C	12%	21%

Revenues from customers by geographic area based on the location of the customers' work sites are as follows (in thousands):

	Year Ended December 31,			
	2019		2018	
	Revenues	Percentage of Revenues	Revenues	Percentage of Revenues
United States	\$ 36,169	42%	\$ 34,179	40%
China	13,960	16	17,465	20
Taiwan	8,574	10	7,890	9
Japan	5,829	7	5,240	6
Rest of the world	21,053	25	21,020	25
Total revenue	\$ 85,585	100%	\$ 85,794	100%

Long-lived assets, net by geographic area is as follows (in thousands):

	December 31,	
	2019(1)	2018(2)
United States	\$ 46,000	\$ 35,173
Rest of the world	2,407	508
Total long-lived assets, net	\$ 48,407	\$ 35,681

(1) Amounts consist of property and equipment, net, and operating lease right-of-use assets, net

(2) Amounts consist of property and equipment, net

14. FINANCIAL INSTRUMENTS

Fair value is the exit price, or the amount that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants as of the measurement date. The multiple assumptions used to value financial instruments are referred to as inputs, and a hierarchy for inputs used in measuring fair value is established, that maximizes the use of observable inputs and minimizes the use of unobservable inputs by requiring that the most observable inputs be used when available. Observable inputs reflect assumptions market participants would use in pricing an asset or liability based on market data obtained from independent sources while unobservable inputs reflect a reporting entity's pricing based upon its own market assumptions. These inputs are ranked according to a fair value hierarchy that prioritizes the inputs to valuation techniques used to measure fair value into three broad levels.

Level 1 - Inputs are quoted prices in active markets for identical assets or liabilities.

Level 2 - Inputs are quoted prices for similar assets or liabilities in an active market, quoted prices for identical or similar assets or liabilities in markets that are not active, inputs other than quoted prices that are observable and market-corroborated inputs which are derived principally from or corroborated by observable market data.

Level 3 - Inputs are derived from valuation techniques in which one or more significant inputs or value drivers are unobservable.

The following table represents the Company's assets measured at fair value on a recurring basis as of December 31, 2019 and the basis for that measurement (in thousands):

Assets	Total	Quoted Prices in Active Markets for Identical Assets (Level 1)	Significant Other Observable Inputs (Level 2)	Significant Unobservable Inputs (Level 3)
Money market mutual funds	\$ 27,644	\$ 27,644	\$ —	\$ —

The following table represents the Company's assets measured at fair value on a recurring basis as of December 31, 2018 and the basis for that measurement (in thousands):

Assets	Total	Quoted Prices in Active Markets for Identical Assets (Level 1)	Significant Other Observable Inputs (Level 2)	Significant Unobservable Inputs (Level 3)
Money market mutual funds	\$ 27,068	\$ 27,068	\$ —	\$ —

The Company enters into foreign currency forward contracts to reduce the exposure to foreign currency exchange rate fluctuations on certain foreign currency denominated monetary assets and liabilities, primarily on third-party accounts payables and intercompany balances. The primary objective of the Company's hedging program is to reduce volatility of earnings related to foreign currency exchange rate fluctuations. The counterparty to these foreign currency forward contracts is a financial institution that the Company believes is creditworthy, and therefore, the Company believes the credit risk of counterparty nonperformance is not significant. These foreign currency forward contracts are not designated for hedge accounting treatment. Therefore, the change in fair value of these contracts is recorded into earnings as a component of other expense (income), net, and offsets the change in fair value of the foreign currency denominated assets and liabilities, which is also recorded in other expense (income), net. For the years ended December 31, 2019 and 2018, the Company recognized a realized loss of \$0.6 million and a realized loss of \$0.7 million, respectively on the contracts, which is recorded in interest and other expense (income), net in the Company's Consolidated Statements of Comprehensive Loss.

The Company carries these derivatives financial instruments on its Consolidated Balance Sheets at their fair values. The Company's foreign currency forward contracts are classified as Level 2 because it is not actively traded and the valuation inputs are based on quoted prices and market observable data of similar instruments. As of December 31, 2019, the Company had no outstanding forward contracts. As of December 31, 2018, the Company had one outstanding forward contract with a notional amount of \$8.2 million and the amount of other current liability associated with the outstanding forward contract was immaterial.

15. SELECTED QUARTERLY FINANCIAL DATA (UNAUDITED)

The following is a summary of the Company's quarterly consolidated results of operations (unaudited) for the fiscal years ended December 31, 2019 and 2018.

	Year Ended December 31, 2019			
	Q1	Q2	Q3	Q4
	(In thousands, except for per share amounts)			
Total revenues	\$ 20,541	\$ 20,568	\$ 21,914	\$ 22,562
Costs of revenues	\$ 7,867	\$ 7,832	\$ 8,715	\$ 9,059
Net loss	\$ (2,691)	\$ (710)	\$ (687)	\$ (1,330)
Net loss per share:				
Basic	\$ (0.08)	\$ (0.02)	\$ (0.02)	\$ (0.04)
Diluted	\$ (0.08)	\$ (0.02)	\$ (0.02)	\$ (0.04)

	Year Ended December 31, 2018			
	Q1	Q2	Q3	Q4
	(In thousands, except for per share amounts)			
Total revenues	\$ 24,737	\$ 21,119	\$ 20,213	\$ 19,725
Costs of revenues	\$ 11,482	\$ 10,917	\$ 10,683	\$ 9,721
Net loss	\$ (424)	\$ (2,096)	\$ (2,082)	\$ (3,114)
Net loss per share:				
Basic	\$ (0.01)	\$ (0.07)	\$ (0.06)	\$ (0.10)
Diluted	\$ (0.01)	\$ (0.07)	\$ (0.06)	\$ (0.10)

Item 9. Changes in and Disagreements with Accountants on Accounting and Financial Disclosure

None.

Item 9A. Controls and Procedures

Evaluation of Disclosure Controls and Procedures

Our management, with the participation of our principal executive officer and principal financial and accounting officer, evaluated the effectiveness of our “disclosure controls and procedures” as defined in Exchange Act Rules 13a-15(e) and 15d-15(e) as of December 31, 2019, in connection with the filing of this Annual Report on Form 10-K. Based on that evaluation, as of December 31, 2019, our principal executive officer and principal financial and accounting officer concluded that our disclosure controls and procedures were effective to ensure that information we are required to disclose in reports that we file or submit under the Exchange Act is recorded, processed, summarized and reported within the time periods specified in the rules and forms of the SEC and is accumulated and communicated to our management as appropriate to allow timely decisions regarding required disclosure.

Management’s Report on Internal Control over Financial Reporting

Our management is responsible for establishing and maintaining adequate internal control over financial reporting, as defined in Rules 13a-15(f) and 15d-15(f) under the Exchange Act, for the Company. Our management, with the participation of our principal executive officer and principal financial and accounting officer, assessed the effectiveness of our internal control over financial reporting as of December 31, 2019. This evaluation was based on the framework established in *Internal Control—Integrated Framework (2013)* issued by the Committee of Sponsoring Organizations of the Treadway Commission (“COSO”). Based on our assessment under the COSO framework, our management concluded that our internal control over financial reporting was effective as of December 31, 2019.

The effectiveness of the Company’s internal control over financial reporting as of December 31, 2019, has been audited by BPM LLP, the Company’s independent registered public accounting firm, as stated in their report which appears in this Annual Report on Form 10-K.

Changes in Internal Control over Financial Reporting

There were no changes in internal control over financial reporting during the fourth quarter ended December 31, 2019, which has materially affected, or is reasonably likely to materially affect, our internal control over financial reporting.

Item 9B. Other Information.

None.

PART III

Pursuant to Paragraph (3) of the General Instructions to Form 10-K, certain of the information required by Part III of this Form 10-K is incorporated by reference from our Proxy Statement as set forth below. The Proxy Statement is expected to be filed within 120 days of December 31, 2019.

Item 10. *Directors, Executive Officers and Corporate Governance.*

Information with respect to our directors and our Audit Committee appears in our Proxy Statement under “Proposal No. 1 — Election of Directors — Nominees for the Board of Directors” and is incorporated herein by reference. Information with respect to our executive officers appears in Part I, Item 1 — “Information about our Executive Officers” of this Form 10-K.

With regard to the information required by this item regarding compliance with Section 16(a) of the Exchange Act, we will provide disclosure of delinquent Section 16(a) reports, if any, in our Proxy Statement, and such disclosure, if any, is incorporated herein by reference.

Our Board of Directors has adopted a Code of Ethics (“Code of Ethics”), which is applicable to our principal executive officer, our principal financial and accounting officer and employees of the Company. Our Code of Ethics is available on our website at www.pdf.com, on the investor relations page. The Company’s website address provided is not intended to function as a hyperlink, and the information on the Company’s website is not, and should not be considered, part of this Annual Report on Form 10-K and is not incorporated by reference herein. You may also request a copy of our Code of Ethics in writing by sending your request to PDF Solutions, Inc., Attention: Investor Relations, 2858 De La Cruz Blvd., Santa Clara, California 95050. If we make any substantive amendments to the Code of Ethics or grant any waiver, including any implicit waiver, from a provision of the Code of Ethics to our Chief Executive Officer or Chief Financial Officer, we will disclose the nature of such amendment or waiver on our website or in a current report on Form 8-K.

Item 11. *Executive Compensation.*

The information required by this item is incorporated herein by reference to the section entitled “Compensation of Executive Officers and Other Matters — Executive Compensation” in our Proxy Statement.

Item 12. *Security Ownership of Certain Beneficial Owners and Management and Related Stockholder Matters.*

The information required by this item is incorporated herein by reference to the section entitled “Security Ownership of Certain Beneficial Owners and Management” in our Proxy Statement. Also incorporated by reference is the information in the table under the heading “Equity Compensation Plan Information” in our Proxy Statement.

Item 13. *Certain Relationships and Related Transactions, and Director Independence.*

The information required by this item is incorporated herein by reference to the section entitled “Certain Relationships and Related Transactions and Directors Independence” in our Proxy Statement.

Item 14. *Principal Accountant Fees and Services.*

Information with respect to Principal Accountant Fees and Services is incorporated by reference to “Proposal No. 2: Ratification of Appointment of Independent Registered Public Accounting Firm” in our Proxy Statement.

PART IV**Item 15. Exhibits and Financial Statement Schedules**

(a) The following documents are filed as part of this report:

- (1) Consolidated Financial Statements and Reports of Independent Registered Public Accounting Firms

The following documents are included as Part II, Item 8 of this Form 10-K:

	Page
Reports of BPM LLP, Independent Registered Public Accounting Firm	35
Consolidated Balance Sheets as of December 31, 2019 and 2018	37
Consolidated Statements of Comprehensive Loss for the Years Ended December 31, 2019 and 2018	38
Consolidated Statements of Stockholders' Equity for the Years Ended December 31, 2019 and 2018	39
Consolidated Statements of Cash Flows for the Years Ended December 31, 2019 and 2018	40
Notes to Consolidated Financial Statements	41

- (2) Financial Statement Schedules

All financial statement schedules have been omitted, since the required information is not applicable or is not present in amounts sufficient to require submission of the schedule, or because the information required is included in the consolidated financial statements and notes thereto included in this Form 10-K.

- (3) Exhibits required by Item 601 of Regulation S-K

See Item 15(b) below.

- (b) Exhibits

INDEX TO EXHIBITS

Exhibit Number	Description
1.01	Board of Directors Acceleration Agreement (incorporated herein by reference to the registrant's Current Report on Form 8-K filed November 23, 2005)*
3.01	Third Amended and Restated Certificate of Incorporation of PDF Solutions, Inc. (incorporated herein by reference to registrant's Registration Statement on Form S-1/A filed July 9, 2001)
3.02	Amended and Restated Bylaws of PDF Solutions, Inc. (incorporated herein by reference to registrant's Quarterly Report on Form 8-K filed May 1, 2019)
4.01	Specimen Stock Certificate (incorporated herein by reference to registrant's Quarterly Report on Form 10-Q filed September 6, 2001)
10.01	Form of Indemnification Agreement between PDF Solutions, Inc. and certain of its executive officers and directors (incorporated herein by reference to registrant's Registration Statement on Form S-1 filed August 7, 2000)
10.02	Form of Indemnification Agreement between PDF Solutions, Inc. and certain of its senior executive officers and directors (incorporated herein by reference to the registrant's Annual Report on Form 10-K filed March 16, 2009)*
10.03	PDF Solutions, Inc. 2001 Stock Plan (incorporated herein by reference to registrant's Quarterly Report on Form 10-Q filed May 10, 2007) and related agreements (incorporated herein by reference to registrant's Quarterly Report on Form 10-Q filed August 9, 2011)*
10.04	PDF Solutions, Inc. 2001 Employee Stock Purchase Plan (incorporated herein by reference to registrant's proxy statement dated April 6, 2010)*

Exhibit Number	Description
10.05	IDS Software, Inc. 2001 Stock Option/Stock Issuance Plan and related agreements (incorporated herein by reference to registrant's Registration Statement on Form S-8 filed October 17, 2003)*
10.06	PDF Solutions Inc. Fifth Amended and Restated 2011 Stock Incentive Plan (incorporated herein by reference to Appendix A to the registrant's proxy statement dated April 30, 2019)*
10.07	Form of Stock Option Agreement (Non-statutory) under PDF Solutions, Inc. 2011 Stock Incentive Plan (incorporated herein by reference to registrant's Annual Report on Form 10-K filed March 15, 2012)*
10.08	Form of Stock Unit Agreement under PDF Solutions, Inc. 2011 Stock Incentive Plan (incorporated herein by reference to registrant's Annual Report on Form 10-K filed March 15, 2012)*
10.09	Form of Stock Appreciation Right Agreement under PDF Solutions, Inc. 2011 Stock Incentive Plan (incorporated herein by reference to registrant's filing on Form 10-Q filed November 9, 2012)*
10.10	Employment confirmation to John Kibarian from PDF Solutions, Inc. dated October 13, 2009 (incorporated herein by reference to registrant's Annual Report on Form 10-K filed March 15, 2012)*
10.11	Employment confirmation to Kimon Michaels from PDF Solutions, Inc. dated October 13, 2009 (incorporated herein by reference to registrant's Annual Report on Form 10-K filed March 15, 2012)*
10.12	Offer letter to Cornelius D. Hartgring from PDF Solutions, Inc. dated August 29, 2002 (incorporated herein by reference to registrant's Annual Report on Form 10-K filed March 26, 2003)*
10.13	Employment Agreement, dated February 26, 2016, with Kwang-Hyun Kim (incorporated herein by reference to registrant's Current Report on Form 8-K, filed March 3, 2016)*
10.14	Employment offer to Christine A. Russell, dated June 27, 2018 (incorporated herein by reference to registrant's filing on Form 10-Q filed on November 9, 2018)*
10.15	Employment offer to Adnan Raza, dated February 14, 2020*
21.01	Subsidiaries of Registrant †
23.01	Consent of BPM LLP, Independent Registered Public Accounting Firm†
31.01	Certifications of the principal executive officer and principal financial and accounting officer pursuant to Exchange Act Rules 13a-14(a) and 15d-14(a), as adopted pursuant to Section 302 of the Sarbanes-Oxley Act of 2002†
31.02	Certifications of the principal executive officer and principal financial and accounting officer pursuant to Exchange Act Rules 13a-14(a) and 15d-14(a), as adopted pursuant to Section 302 of the Sarbanes-Oxley Act of 2002†
32.01	Certification pursuant to 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002**
32.02	Certification pursuant to 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002**
101.INS	XBRL Instance Document†
101.SCH	XBRL Taxonomy Extension Schema Document†
101.CAL	XBRL Taxonomy Extension Calculation Linkbase Document†
101.DEF	XBRL Taxonomy Extension Definition Linkbase Document†
101.LAB	XBRL Taxonomy Extension Labels Linkbase Document†
101.PRE	XBRL Taxonomy Extension Presentation Linkbase Document†

* Indicates management contract or compensatory plan or arrangement.

† Filed herewith.

** Furnished, and not filed.

Item 16. Form 10-K Summary

Not applicable.

SIGNATURES

Pursuant to the requirements of Section 13 or 15(d) of the Securities Exchange Act of 1934, the Registrant has duly caused this report to be signed on its behalf by the undersigned, thereunto duly authorized.

PDF SOLUTIONS, INC.

By: /s/ John K. Kibarian

John K. Kibarian
President and Chief Executive Officer
(Principal executive officer)

By: /s/ Christine A. Russell

Christine A. Russell
Executive Vice President, Finance and Chief Financial
Officer
(Principal financial and accounting officer)

Date March 10, 2020

Pursuant to the requirements of the Securities Exchange Act of 1934, this report has been signed below by the following persons on behalf of the registrant and in the capacities and on the dates indicated.

Date	Signature	Title
March 9, 2020	<u>/s/ JOHN K. KIBARIAN</u> John K. Kibarian	Director, President and Chief Executive Officer (Principal executive officer)
March 9, 2020	<u>/s/ CHRISTINE A. RUSSELL</u> Christine A. Russell	Executive Vice President, Finance and Chief Financial Officer (Principal financial and accounting officer)
March 9, 2020	<u>/s/ JOSEPH R. BRONSON</u> Joseph R. Bronson	Lead Independent Director
March 9, 2020	<u>/s/ MARCO IANSITI</u> Marco Iansiti	Director
March 9, 2020	<u>/s/ KIMON MICHAELS</u> Kimon Michaels	Director
March 9, 2020	<u>s/ GERALD Z. YIN</u> Gerald Z. Yin	Director
March 9, 2020	<u>s/ MICHAEL B. GUSTAFSON</u> Michael Gustafson	Director
March 9, 2020	<u>s/ NANCY ERBA</u> Nancy Erba	Director
March 9, 2020	<u>s/ SHUO ZHANG</u> Shuo Zhang	Director

PDF Solutions, Inc.
2858 De La Cruz Boulevard
Santa Clara, California 95050 USA

January 23, 2020

Adnan Raza
VIA EMAIL

Re: Employment Offer

Dear Adnan,

On behalf of PDF Solutions, Inc. (the “**Company**”), I am pleased to extend to you this offer of full-time employment. Your position will be that of **Executive Vice President, Finance**, reporting to me, however, notwithstanding the “Executive Vice President” title, this position will not have policy-making authority. Subject to appointment by PDF’s Board of Directors at a date thereafter to be decided in the Company’s discretion, it is the Company’s intention that your position will become that of **Chief Financial Officer**, which position does for clarification have policy-making authority, and at which point you will become a Named Executive Officer of the Company and subject to Section 16 filing requirements. You will be based in our San Jose area office, currently at 2858 De La Cruz Blvd., Santa Clara, CA 95050. This offer of employment with PDF is conditioned upon your acceptance, in writing, of the terms and conditions as enumerated below.

1. **Compensation.** Commencing on your Start Date (as defined below), you shall be paid a base salary of **THREE HUNDRED TEN THOUSAND** U.S. dollars (**\$310,000**) per annum, paid to you semi-monthly at the rate of **\$12,916.67** per payroll period. Your salary shall be paid in accordance with the Company’s standard payroll policies (subject to applicable withholding taxes as required by law). Your salary will be reviewed by the Compensation Committee each year and adjusted in their discretion, if at all.
 2. **Pay for Performance Compensation Program (“PPCP”).** Named Executive Officer (“**NEOs**”) are eligible to participate in our Company-sponsored Pay for Performance Compensation Program of which the structure of such plans and the amount of any bonus awarded under such plans is defined and governed by the Compensation Committee of the Board of Directors (and subject to change based on Compensation Committee approval). The pay-for-performance component of our executive compensation program as it applies to the calendar year period as the performance period under the PPCP, will be based on specific goals set by the Compensation Committee, which currently include revenue and non-GAAP profitability. Currently as outlined in the program, 50% of each eligible participant’s total annual cash incentive bonus opportunity and 50% of each eligible participant’s total annual equity opportunity will be subject to achievement of the goals under the PPCP (the remaining percentage of total annual cash incentive bonus opportunity is provided via the Company’s Annual Discretionary Incentive Bonuses program described in Section 3 and the remaining percentage of total annual equity opportunity is provided via the Company-sponsored Annual Discretionary Long-Term Equity Incentive Awards program described in Section 4). All cash incentive bonus payouts are conditioned on you being an employee at the time of such payment and are subject to applicable withholding taxes as required by law.
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3. **Annual Discretionary Incentive Bonuses.** NEO's are eligible to participate in our Company-sponsored Annual Discretionary Incentive Bonuses program. The percentage of each eligible participant's total annual cash incentive bonus opportunity that is not subject to the PPCP (the "Discretionary Bonus") will be based on achieving performance objectives as determined by the Compensation Committee. All Annual Discretionary Incentive Bonuses program payouts are conditioned on you being an employee at the time of such payment and are subject to applicable withholding taxes as required by law.

However, in any case, your guaranteed minimum cash bonus for the 2020 calendar year performance period is **SEVENTY SEVEN THOUSAND FIVE HUNDRED** U.S. dollars (**\$77,500**) prorated based on Start Date, which will be paid in 2021 when other NEOs' 2020 bonuses are paid and, in any event, no later than March 30, 2021.

4. **Annual Discretionary Long-Term Equity Incentive Awards.** NEOs are eligible to participate in our Company-sponsored Annual Discretionary Long-Term Equity Incentive Awards program. The percentage of each eligible participant's total annual equity opportunity that is not subject to the PPCP (the "Discretionary Equity Award") will be based on achieving performance objectives as determined by the Compensation Committee of the Board of Directors and granted with the Company-wide merit/refresh awards in the Compensation Committee's discretion, which is typically around May – June each year.
5. **Restricted Stock Units.** As soon as practicable following the commencement of your employment, and subject to approval of the Compensation Committee of the grant, you will be awarded a restricted stock unit ("RSU") for **120,000 shares** (the "**Total RSUs**") of the Company's Common Stock. This award is subject to the terms of the Company's 2011 Stock Plan (as amended and restated). Such RSUs are generally granted and start vesting (the "RSU Vesting Start Date") on the first day of the month following the month the award is approved according to the following vesting schedule: 25% of Total RSUs shall vest (and shares will be issued) on **12/31/20** and 12.5% of the total RSUs shall vest on the date that is 18 months after the RSU Vesting Start Date and thereafter 12.5% of the Total RSUs shall vest (and shares will be issued) every six (6) months thereafter until fully vested, subject to your continued service through each applicable vesting date.
6. **Start Date.** This offer is contingent upon the satisfactory completion of reference/background/credit checks. Subject to fulfillment of any conditions imposed by this letter agreement, you will commence your new position with the Company on a date to be determined and agreed upon with the Company. Your "Anticipated Start Date" is currently expected by the Company to be **January 28, 2020**. The date you actually start working at the Company is referred to as your "**Start Date**."
7. **General Duties.** During the term of your employment, you agree that at all times and to the best of your ability you will loyally and conscientiously perform all of the duties and obligations required of you in your job and by the Company. You further agree that you will not render commercial or professional services of any nature to any person or organization, whether or not for compensation, without the prior written consent of the Company, and that you will not directly or indirectly engage in or participate in any business that is competitive in any manner with the business of the Company. You also agree to comply with any and all policies of the Company as in effect from time to time.
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8. **Proof of Right to Work.** In compliance with federal immigration laws, you will be required to provide to the Company documentary evidence of your identity and eligibility for employment in the United States. Such documentation must be provided within three (3) business days of your Start Date. Your failure to meet this condition could result in termination of your employment with the Company.
 9. **Benefits.** Effective on the first day of the month following your Start Date, the Company will make available to you the regular health insurance program and other benefits as established by the Company for its employees from time to time.
 11. **Change of Control.** In the event that the Company undergoes a Change in Control (as defined below) after your Start Date and, at any time over the next twelve (12) months after consummation of such Change of Control your employment is terminated without Cause or as a result of your Disability or you resign with Good Reason (as such terms are defined below), then following your Separation and upon meeting the Separation Conditions (as such terms are defined below) you will be entitled to all of the following:
 - (i) Full vesting acceleration of your then outstanding and unvested stock options, RSUs and any other forms of equity, effective as of the Release Deadline Date (as defined below);
 - (ii) severance equal to twelve (12) months of your then-current annual base salary, paid in a single lump sum payment on the Company's first regular payroll date following the Release Deadline Date (subject to applicable withholding taxes required by law);
 - (iii) additional severance of a one-time "bonus" equal to fifty percent (50%) of your then-current base salary, which will be paid in a single lump sum payment on the Company's first regular payroll date following the Release Deadline Date (subject to applicable withholding taxes required by law); and,
 - (iv) the Company's portion of the health insurance premium paid just prior to termination to supplement your COBRA coverage from the last date on which you receive health care coverage as a Company employee until the earlier of: (1) the date the Company has paid for twelve (12) months of COBRA premiums; or (2) the date you become eligible to be covered under another employer's health coverage plan, with the first of such premium payments made when due immediately following the date on which you have made your COBRA election, which you will elect within sixty (60) days following your Separation Date; provided that the Company shall treat any payment of COBRA premiums as taxable to the extent required to avoid adverse consequences to you or the Company under either Section 105(h) of the Internal Revenue Code of 1986, as amended (the "Code") or the Patient Protection and Affordable Care Act of 2010.
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12. **Termination without Cause or Disability.** In the event the Company terminates your employment at any time without Cause or as a result of your Disability and a Separation occurs, then subject to the Separation Conditions, you will be entitled to all of the following:
- (i) vesting acceleration of your then outstanding and unvested stock options and RSUs as if you provided continuous service to the Company for an additional six (6) months after your Separation Date, effective as of the Release Deadline Date;
 - (ii) severance equal to six (6) months of your then-current annual base salary, paid in accordance with the Company's standard payroll procedures over a six-month period, with the first payment commencing on the Company's first regular payroll date following the Release Deadline Date (subject to applicable withholding taxes required by law); provided that the first payment shall be equal to the number of business days between the Separation Date and the date of the first payment multiplied by your daily base salary rate;
 - (iii) additional severance equal to fifty percent (50%) of each of the PPCP annual cash incentive bonus and annual Discretionary Bonus paid to you for the immediately preceding performance period, which will be paid in a single lump sum payment on the Company's first regular payroll date following the Release Deadline Date (subject to applicable withholding taxes required by law); and
 - (iv) the Company's portion of the health insurance premium paid just prior to termination to supplement your COBRA coverage from the last date on which you receive health care coverage as a Company employee until the earlier of: (1) the date the Company has paid for six (6) months of COBRA premiums; or (2) the date you become eligible to be covered under another employer's health coverage plan, with the first of such premium payments made when due immediately following the date on which you have made your COBRA election, which you will elect within sixty (60) days following your Separation Date; provided that the Company shall treat any payment of COBRA premiums as taxable to the extent required to avoid adverse consequences to you or the Company under either Code Section 105(h) or the Patient Protection and Affordable Care Act of 2010.
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13. **Definitions.** As used in this letter:

- (a) "Cause" means (i) your unauthorized use or disclosure of the Company's confidential information or trade secrets; (b) your material breach of any agreement between you and the Company, which remains uncured by you more than five (5) days from the date of your receipt of written notice of such material breach from the Company; (c) your repeated or material failure to comply with the Company's written policies or rules, including without limitation the Company's Code of Ethics, and including actions or omissions for which the Company undergoes more than one formal investigation for potential violations; (d) your conviction of, or your plea of "guilty" or "no contest" to, a felony under the laws of the United States or any State; (e) your gross negligence or willful misconduct; (f) your continuing failure to perform or initiating performance of assigned duties for which there is no reasonable basis for you disputing and/or failing to so perform for ten (10) days after receiving written notification of the failure from the Board of Directors; or, (g) your failure to cooperate in good faith with a governmental or internal investigation of the Company or its directors, officers or employees, if the Company has requested your cooperation.
 - (b) "Change of Control" means a change in ownership or control of the Company effected through the sale of all or substantially all of the Company's assets, a merger, consolidation or acquisition by any person or related group of persons (other than an acquisition by the Company or by a Company-sponsored employee benefit plan or by a person or persons that directly or indirectly controls, is controlled by, or is under common control with, the Company) of beneficial ownership (within the meaning of Rule 13d-3 of the Securities Exchange Act of 1934) of securities possessing more than fifty percent (50%) of the total combined voting power of the outstanding securities of the Company.
 - (c) "Disability" means your inability to perform the essential functions of your position, with reasonable accommodation, for a period of one hundred and twenty (120) consecutive days because of your physical or mental impairment, provided your disability also qualifies as a "disability" as defined in the regulations under Section 409A (as defined below).
 - (d) "Good Reason" means that within three (3) months before or twelve (12) months after consummation of a Change of Control, (i) your base salary is reduced to an amount that is less than 95% of the amount set forth in this letter, (ii) your annual targeted PPCP cash incentive and annual targeted Discretionary Bonus is reduced to an amount that is less than 95% of the target set by the Compensation Committee for the then-current performance period, (iii) you are demoted by means of a material reduction in authority, responsibilities, duties, or (iv) you are required to continue employment from a location more than 50 miles from your current home address (94303 zip code), in any case, if you give the Company (or its successor) written notice of the condition within thirty (30) days after the condition first comes into existence and the Company (or its successor) fails to remedy the short-fall within thirty (30) days after receiving your written notice.
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- (e) "Release" means the Company's standard general release of all claims, substantially similar to what has been provided to you in connection with entering into this offer, that you may have against the Company or persons affiliated with the Company, subject to good-faith negotiation between you and the Company.
- (f) "Separation" means a "separation from service," as defined in the regulations under Section 409A.
- (g) "Separation Conditions" means you have (i) returned all Company property in your possession promptly after your Separation Date and, in any event, no later than ten (10) days after your Separation Date; and, (ii) executed the Release, and not revoked it through any deadline applicable to such revocation, such that the Release is effective within sixty (60) days after your Separation Date (the "Release Deadline Date"). The foregoing condition in subsection (ii) is contingent on the Company delivering the form of release to you within two (2) days after your Separation Date.
- (h) "Separation Date" means the date that the termination or resignation of your employment becomes an effective Separation.

14. **Tax Considerations.** For purposes of Code Section 409A, the regulations and other guidance there under and any state law of similar effect (collectively "Section 409A"), each payment that is paid, and benefit that is provided, pursuant to this agreement is hereby designated as a separate payment. The parties intend that all payments made or to be made, and benefits provided or to be provided, under this agreement comply with, or are exempt from, the requirements of Section 409A so that none of the payments or benefits will be subject to the adverse tax penalties imposed under Section 409A, and any ambiguities herein will be interpreted to so comply or be so exempt. Specifically, any severance payments or benefits made in connection with your Separation under this agreement and paid or provided on or before the fifteenth (15th) day of the third (3rd) month following the end of your first (1st) tax year in which your Separation occurs or, if later, the fifteenth (15th) day of the third (3rd) month following the end of the Company's first (1st) tax year in which your Separation occurs, shall be exempt from Section 409A to the maximum extent permitted pursuant to Treasury Regulation Section 1.409A-1(b)(4) and any additional severance payments and benefits provided in connection with any Separation are intended to be exempt from Section 409A pursuant to Treasury Regulation Section 1.409A-1(b)(9)(iii). Notwithstanding anything set forth herein, to the extent that the severance payments and/or benefits provided in this letter do not qualify for any reason to be exempt from Section 409A pursuant to Treasury Regulation Section 1.409A-1(b)(4), Treasury Regulation Section 1.409A-1(b)(9)(iii), or any other applicable exemption, as described herein, and as reasonably determined by the Company, and the Company determines that you are a "specified employee" under Section 409A(a)(2)(B)(i) of the Code at the time of the Separation, then, to the extent required by Section 409A, all payments and benefits that otherwise would have been paid or provided during the first six (6) months after the effective date of the Separation will be paid in a lump sum or provided on the first (1st) day of the seventh (7th) month after the Separation.
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You are encouraged to obtain your own tax advice regarding your compensation from the Company. You agree that the Company does not have a duty to design its compensation policies in a manner that minimizes your tax liabilities, and you will not make any claim against the Company or its Board of Directors related to tax liabilities arising from your compensation or any severance paid hereunder.

15. **Confidential Information and Invention Assignment Agreement.** Your acceptance of this offer and commencement of employment with the Company is contingent upon your execution of the Company's Confidential Information and Invention Assignment Agreement (the "**Confidentiality Agreement**"), a copy of which is enclosed for your review. An executed copy of the Confidentiality Agreement must be delivered to the PDF Human Resources Department on or before your Start Date. The Confidentiality Agreement relates to confidential information received in regards to the Company's business, technology, and intellectual property, as well as information about the Company's customers. The Confidentiality Agreement also addresses the Company's ownership of intellectual property generated during your employment at the Company. You are required, to the best of your ability, to hold such information as confidential even after an event terminating your employment with the Company.
 16. **Arbitration.** Any dispute, claim or controversy between you as Employee and PDF Solutions as Employer arising out of or relating to (i) our employment relationship or any of the events or circumstances leading up to your employment with PDF Solutions including, without limitation, your interview process and all negotiations relating to your employment with PDF Solutions and the execution of this agreement; and/or (ii) this agreement or any of its provisions, or the breach, termination, enforcement, interpretation or validity thereof, shall be subject to and resolved exclusively by arbitration before a single arbitrator in accordance with the National Rules for the Resolution of Employment Disputes, also called the "Employment Arbitration Rules and Mediation Procedures"(the "Rules") of the American Arbitration Association (the "AAA"), a copy of which can be found as of the date of this letter at the following internet website: <https://www.adr.org/sites/default/files/Commercial%20Rules.pdf> Such Rules of the AAA in effect at the time of your accepting this offer of employment and entering this agreement by that acceptance are to be used, provided that they remain applicable and do not contravene applicable law at the time of any actual arbitration. The single arbitrator will be selected by the AAA pursuant to its Rules. The decision of the arbitrator and any arbitration award shall be final, binding, non-appealable and conclusive on and as to the parties thereto. No recourse may be made to any court except solely to enforce a final award in a court of competent jurisdiction. California law, without regard to conflict of law principles or the choice of law provisions of other states, applies to this agreement to arbitrate, as well as exclusively to all other matters regarding your employment or arising respecting it at any time, except to the extent that the Federal Arbitration Act (FAA) and federal law regarding arbitration is applicable, in which case as to those issues, federal law governs. In this regard, it is acknowledged that the employee's employment is specifically understood to "involve commerce" and that the FAA governs and applies in those circumstances. The provisions of this offer letter, specifically including the agreement to arbitrate, are the product of arm's length negotiations with you and they are agreed to and are entered after due consideration and voluntarily with the intention to be bound by them, including the agreement to arbitrate, and it is agreed and acknowledged that this is an individually negotiated agreement and plan, not an employer-promulgated plan, and that you have been given the opportunity to have this agreement, including the provision for arbitration, reviewed prior to our signing by counsel of your own choice and at your sole expense.
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17. **At-Will Employment and Other Conditions.** Your employment will be at-will, meaning that you or PDF may terminate the employment relationship at any time, with or without cause, with or without notice ("At-Will"). This offer is contingent upon: (i) receiving satisfactory references from former employers, (ii) Satisfactory completion of a background investigation and credit check, (iii) Verification of your right to work in the United States, as demonstrated by your completion of the I-9 form upon hire and your submission of acceptable documentation (as noted on the I-9 form) verifying your identity and work authorization within three days of starting employment. (iv) Your execution of PDF's Agreements and Policies as enclosed, that need to be executed prior to commencing work and (v) PDF's receiving verification that you hold the following qualification(s) as listed in your resume. Your failure to meet these conditions individually or collectively could result in termination of your employment with the Company.

 18. **Severability; Electronic Signature.** If any provision of this offer is determined to be invalid or unenforceable, the remainder shall be unaffected and shall be enforceable. This offer may be executed by one or both parties electronically, and in counterparts, each of which shall be deemed an original and all of which together shall be deemed one and the same original agreement.
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We are all delighted to be able to extend you this offer and look forward to working with you. Should you have any additional questions, please reach out to VP of HR, Pamela Fong. To indicate your acceptance of this offer, please sign and date this letter in the space provided below and return a scanned copy to Pamela by email.

Sincerely,

PDF SOLUTIONS, INC.

/s/ John K. Kibarian
Chief Executive Officer and President

ACKNOWLEDGMENTS & ACCEPTANCE

I accept this employment offer with the understanding that it is not a contract for a fixed term or specified period of time. I understand that my employment is voluntary, (“**At Will**”), and can be terminated either by me or by the company at any time, with or without notice and with or without cause. The provisions stated above supersede all prior representations or agreements, whether written or oral. This offer letter may not be modified or amended except by a written agreement, signed by the Company and me.

THE FOREGOING TERMS AND CONDITIONS ARE HEREBY AGREED TO AND ACCEPTED:

Signed: /s/ Adnan Raza

Name: Adnan Raza Date: January 27, 2020

Subsidiaries of Registrant**Name of Entity****Jurisdiction of Incorporation or Organization**

PDF Solutions GmbH	Germany
PDF Solutions KK	Japan
PDF Solutions SARL	France
PDF Solutions Semiconductor Technology (Shanghai) Co. Ltd.	China
PDF Solutions Semiconductor Technology (Korea) Limited	Korea
PDF Solutions International Services, Inc.	Delaware
PDF Solutions Asia Services, Inc.	Delaware
PDF Solutions Semiconductor Technology Taiwan Ltd.	Taiwan
PDF Solutions Pacific Services, Inc.	Delaware
PDF Solutions Canada Ltd	Canada
Syntricity, Inc.	California

CONSENT OF INDEPENDENT REGISTERED PUBLIC ACCOUNTING FIRM

We hereby consent to the incorporation by reference and in the Registration Statements on Form S-8 (Nos. 333-233070, 333-167533, 333-66758, 333-202455, 333-180324, 333-167533, 333-159211, 333-149281, 333-141660, 333-133332, 333-112728, 333-109809, 333-102509 and 333-66758) of PDF Solutions, Inc. of our reports dated March 10, 2020 relating to the consolidated financial statements and internal control over financial reporting which appear in this Annual Report on Form 10-K.

/s/ BPM LLP
San Jose, California
March 10, 2020

CERTIFICATIONS

I, John K. Kibarian, certify that:

1. I have reviewed this annual report on Form 10-K of PDF Solutions, Inc.;

2. Based on my knowledge, this report does not contain any untrue statement of a material fact or omit to state a material fact necessary to make the statements made, in light of the circumstances under which such statements were made, not misleading with respect to the period covered by this report;

3. Based on my knowledge, the financial statements, and other financial information included in this report, fairly present in all material respects the financial condition, results of operations and cash flows of the registrant as of, and for, the period presented in this report;

4. The registrant's other certifying officer(s) and I are responsible for establishing and maintaining disclosure controls and procedures (as defined in Exchange Act Rules 13a-15(e) and 15d-15(e)) and internal control over financial reporting (as defined in Exchange Act Rules 13a-15(f) and 15d-15(f)) for the registrant and have:

(a) Designed such disclosure controls and procedures, or caused such disclosure controls and procedures to be designed under our supervision, to ensure that material information relating to the registrant, including its consolidated subsidiaries, is made known to us by others within those entities, particularly during the period in which this report is being prepared;

(b) Designed such internal control over financial reporting, or caused such internal control over financial reporting to be designed under our supervision, to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles;

(c) Evaluated the effectiveness of the registrant's disclosure controls and procedures and presented in this report our conclusions about the effectiveness of the disclosure controls and procedures, as of the end of the period covered by this report based on such evaluation; and

(d) Disclosed in this report any change in the registrant's internal control over financial reporting that occurred during the registrant's most recent fiscal quarter (the registrant's fourth fiscal quarter in the case of an annual report) that has materially affected, or is reasonably likely to materially affect, the registrant's internal control over financial reporting; and

5. The registrant's other certifying officer(s) and I have disclosed, based on our most recent evaluation of internal control over financial reporting, to the registrant's auditors and the audit committee of registrant's board of directors (or persons performing the equivalent functions):

(a) All significant deficiencies and material weaknesses in the design or operation of internal control over financial reporting which are reasonably likely to adversely affect the registrant's ability to record, process, summarize and report financial information; and

(b) Any fraud, whether or not material, that involves management or other employees who have a significant role in the registrant's internal control over financial reporting.

/s/ John K. Kibarian

John K. Kibarian

President and Chief Executive Officer

(principal executive officer)

March 10, 2020

CERTIFICATIONS

I, Christine A. Russell, certify that:

1. I have reviewed this annual report on Form 10-K of PDF Solutions, Inc.;
2. Based on my knowledge, this report does not contain any untrue statement of a material fact or omit to state a material fact necessary to make the statements made, in light of the circumstances under which such statements were made, not misleading with respect to the period covered by this report;
3. Based on my knowledge, the financial statements, and other financial information included in this report, fairly present in all material respects the financial condition, results of operations and cash flows of the registrant as of, and for, the periods presented in this report;
4. The registrant's other certifying officer(s) and I are responsible for establishing and maintaining disclosure controls and procedures (as defined in Exchange Act Rules 13a-15(e) and 15d-15(e)) and internal control over financial reporting (as defined in Exchange Act Rules 13a-15(f) and 15d-15(f)) for the registrant and have:
 - (a) Designed such disclosure controls and procedures, or caused such disclosure controls and procedures to be designed under our supervision, to ensure that material information relating to the registrant, including its consolidated subsidiaries, is made known to us by others within those entities, particularly during the period in which this report is being prepared;
 - (b) Designed such internal control over financial reporting, or caused such internal control over financial reporting to be designed under our supervision, to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles;
 - (c) Evaluated the effectiveness of the registrant's disclosure controls and procedures and presented in this report our conclusions about the effectiveness of the disclosure controls and procedures, as of the end of the period covered by this report based on such evaluation; and
 - (d) Disclosed in this report any change in the registrant's internal control over financial reporting that occurred during the registrant's most recent fiscal quarter (the registrant's fourth fiscal quarter in the case of an annual report) that has materially affected, or is reasonably likely to materially affect, the registrant's internal control over financial reporting; and
5. The registrant's other certifying officer(s) and I have disclosed, based on our most recent evaluation of internal control over financial reporting, to the registrant's auditors and the audit committee of registrant's board of directors (or persons performing the equivalent functions):
 - (a) All significant deficiencies and material weaknesses in the design or operation of internal control over financial reporting which are reasonably likely to adversely affect the registrant's ability to record, process, summarize and report financial information; and
 - (b) Any fraud, whether or not material, that involves management or other employees who have a significant role in the registrant's internal control over financial reporting.

/s/ Christine A. Russell

Christine A. Russell

Executive Vice President, Finance and Chief Financial Officer

(Principal financial and accounting officer)

March 10, 2020

**CERTIFICATION PURSUANT TO
18 U.S.C. SECTION 1350,
AS ADOPTED PURSUANT TO
SECTION 906 OF THE SARBANES-OXLEY ACT OF 2002**

In connection with the Annual Report of PDF Solutions, Inc. (the "Company") on Form 10-K for the year ended December 31, 2019 as filed with the Securities and Exchange Commission on March 10, 2020 (the "Report"), I, John K. Kibarian, President and Chief Executive Officer of the Company, certify, pursuant to 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002, that, to my knowledge:

- (1) The Report fully complies with the requirements of section 13(a) or 15(d) of the Securities Exchange Act of 1934; and
- (2) The information contained in the Report fairly presents, in all material respects, the financial condition and result of operations of the Company.

/s/ John K. Kibarian

John K. Kibarian
President and Chief Executive Officer
(principal executive officer)

March 10, 2020

**CERTIFICATION PURSUANT TO
18 U.S.C. SECTION 1350,
AS ADOPTED PURSUANT TO
SECTION 906 OF THE SARBANES-OXLEY ACT OF 2002**

In connection with the Annual Report of PDF Solutions, Inc. (the "Company") on Form 10-K for the year ended December 31, 2019 as filed with the Securities and Exchange Commission on March 10, 2020 (the "Report"), I, Christine A. Russell, Executive Vice President, Finance and Chief Financial Officer of the Company, certify, pursuant to 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002, that, to my knowledge:

- (1) The Report fully complies with the requirements of section 13(a) or 15(d) of the Securities Exchange Act of 1934; and
- (2) The information contained in the Report fairly presents, in all material respects, the financial condition and result of operations of the Company.

/s/ Christine A. Russell

Christine A. Russell
*Executive Vice President, Finance and Chief Financial
Officer*
(principal financial and accounting officer)

March 10, 2020