Research and Development

Research and Development for the Future

Digital technology is becoming an increasingly familiar part of people’s lives, such as online education and medical services, remote work, and the emergence of various services utilizing AI. The evolution of IT applications and the diversification of services are expected to continue. As a support for the evolution of such digital technology, semiconductors will become increasingly necessary in the future, and more advanced and diversified technologies will be required for semiconductor manufacturing. At Tokyo Electron, we discuss the role we should play for the future on a daily basis, and are working company-wide on research and development with an eye on future technology markets.

Market Heading toward Diversification

Applications increase as manufacturing technologies diversify

Development System

In the ever-diversifying area of semiconductor production technology, we have built a system to bring high-value-added products into the market in a timely fashion, promoting technology development and technology innovation for the next generations with collaboration between our Development & Production Group and Business Group. We share technology roadmaps spanning multiple generations for the future with our customers, and work with relevant divisions across the company in converting that technology to equipment in anticipation of their needs.

Specifically, the Corporate Innovation Division, which is headed by the Representative Director, President & CEO, along with the development divisions of the manufacturing sites in Japan and the marketing departments of business units, are leading efforts to enhance process integration capabilities based on our wide lineup of semiconductor production equipment and to promote and develop digital transformation utilizing AI technology. In January 2020, we established TEL Manufacturing and Engineering of America to optimize development and manufacturing functions and improve operational efficiency not only in Japan but in the U.S. as well. Since then, the company has been pushing ahead with activities.

Furthermore, with regard to environment, health and safety (EHS), which is becoming increasingly important as societal demands escalate, the EHS Council, which oversees our entire company, is playing a pivotal role in promoting the review and formulation of basic policies. Each of our manufacturing sites in Japan are also actively working to pursue company-wide on research and development with an eye on future technology markets.
**Shift Left**

We are focused on advancing the Shift Left approach, including investing in research and development (R&D) and technology. This is achieved through participation in a global research hub developing next-generation AI hardware, by cooperating with BRIDG, a not-for-profit, public-private partnership located in the state of Florida, by strengthening collaboration in the field of EUV at imec and by accelerating our research in the areas of semiconductor materials deposition for microelectronics and micromachining.

In fiscal year 2021, responding to the ongoing customer need for production equipment to take up less space, we succeeded in improving equipment efficiency per unit area by maximizing the use of clean rooms and providing more productive equipment. We also established new goals and strengthened our efforts to meet the environmental demands of customers for equipment.

We are promoting the Shift Left approach as a result of our commitment to continuously improving our development and manufacturing processes, as well as to enhancing our product competitiveness.

**Product Marketing**

We are promoting effective product development by having our sales departments and product marketing departments actively play their respective roles. Our sales departments are responsible for building relationships of trust with customers and ensuring that products and services are provided through business to the customers they serve. Meanwhile, our product marketing departments plan and manage product strategies that meet the future needs of customers in target markets, such as development planning to increase the value of customer products, services, and the examination of value-adding mechanisms.

They also consider the commercialization of technology, and the addition of functions based on the seeds of our development.

We are promoting early delivery of evaluation units at customers’ production lines, and standardizing our mass production line equipment. We also promote on-site collaboration for early delivery of evaluation units at customers’ production lines, and standardizing our mass production line equipment.

**Collaboration with Consortiums and Academia**

We are enhancing our own research and development capabilities through collaboration with international and domestic consortiums which allows us to further our development of leading-edge technologies. Specifically, we are focusing on collaboration in a wide range of areas, from development to market launch of rapidly evolving technologies and applications. This is achieved through participation in a global research hub developing next-generation AI hardware, by cooperating with BRIDG, a not-for-profit, public-private partnership located in the state of Florida, by strengthening collaboration in the field of EUV at imec and by accelerating our research in the front-end and back-end fields at TTA.

We are also working on various collaborations with academia, including major universities in Japan. In particular, we are promoting collaboration in a wide range of fields with the National Institute of Advanced Industrial Science and Technology (AIST)—one of Japan’s largest public research institutions—along with the MirAI-related research that we have been working on for some time in the field of semiconductor development, which is increasingly diverse, we will further strengthen our own research and development by leveraging AIST’s world-leading research environment and world-class research staff.

**Initiatives in Japan**

Since 2018, we have been conducting a joint research selection program with universities with the aim of discovering and collaborating on advanced element technologies in relation to semiconductors. Over the past three years, 16 topics have been chosen for joint research. Although applicants are free to propose any research topics, we adopt those proposals that match our technological abilities and needs and which are expected to help develop our technological and planning capabilities and contribute to the future development of our business areas through the creative perspectives and ideas only possible in academia.

Technical advisors selected from our development divisions and business units (BU) are in charge of selecting topics, with subsequent joint research activities managed by a secretariat. Technical advisors strive to generate research results by promoting technical assessment with the university, and at the end of the research period, where outcomes are found to be effective, the topics are considered by our BUs for ongoing research.

In addition to promoting the development of a wide range of semiconductor-related technology and devices, we are promoting the selection program in an effort to contribute to the evolution of science and technology and the revitalization of research activities at universities.

**Intellectual Property Management**

Our fundamental tenet for intellectual property (IP) is to protect our intellectual assets and contribute to increasing corporate revenue through the support of our business activity.

In our uniquely evolving industry, we have increased the global investment in research and development, including industry-academia collaborative initiatives that synergistically grow our business. We establish regional IP offices, as well as corporate headquarters, to locate IP personnel at research, development, and production sites worldwide. Those IP personnel assess each project from various angles, including R&D and marketing perspectives, building IP portfolios aligned with technology, and product strategies in an effort to boost competitiveness.

We sustained our worldwide advantage in the IP strength again in calendar year 2020. 1,180 inventions were created in the second half of 2020, representing 70% for the tenth consecutive year and achieved high patent approval rates (85% in Japan and 87% in the United States).

We have maintained a global patent application rate of approximately 70% for the tenth consecutive year and achieved high patent approval rates (85% in Japan and 87% in the United States). The number of joint patent applications in collaboration with other companies, universities and other research institutes around the world has reached 25, with 13 companies and 8 organizations in the last two years.

We have also advanced our intellectual property strategy, and in total, around 4,370 engineers have become inventors. Additionally, because we often handle highly confidential information, including technological information of our customers and collaborative partners, we have also focused on confidential information management education.
Tackling Technological Innovation

Research and Development for Next-Generation Computing

Global demand for semiconductors has been increasing in recent years, and the production volume of semiconductors is expected to continue increasing. Under such circumstances, reducing the power consumption of semiconductors has become a major issue. We recognize this issue as an energy supply risk in the market, and are working for a solution.

Modern computing is not necessarily optimized for power efficiency. The mainstream solution to this problem is to optimize the architecture, placing memory devices closer to logic devices (arithmetic circuits), resulting in a considerable reduction in power consumption. One of the technologies that make this "optimization of architecture" possible is 3D system integration. Also called "heterogeneous integration," 3D system integration technology is one that combines and packages different materials such as silicon and non-silicon elements, CPUs and DRAMs. Specific combinations applying this technology are expected to reduce power consumption to between 1/100th and 1/1000th of conventional architecture.

Furthermore, the development of resistive analog neural devices and nonvolatile resistive random access memory that simulate the human brain is essential to the evolution of AI technology, and our film deposition technology is contributing to this.

Realizing next-generation computing requires the development of AI chipsets with even faster processing and greater energy efficiency. By taking maximum advantage of a wide range of technologies and various techniques, we are working to create high-value-added products that meet the next-generation need of bringing computers closer to the human brain. To this end, we are expanding further the technological areas in which we can contribute, such as developing new materials and boosting the performance of chipsets through 3D system integration, and we are rolling out initiatives aimed at optimizing the power efficiency of semiconductors and realizing next-generation computing.

Support for Evolving Displays

With the evolution of communications technology such as IoT and 5G, further performance improvements are also expected for displays that project all kinds of information into the real world. In addition to higher image quality and lower power consumption, there is also a growing need for built-in sensors and greater flexibility of design. Organic Light Emitting Diode (OLED) displays, which are widely used in smartphones and televisions, are expected to expand to a wide range of applications, including IT and automotive, because of their high image quality and design qualities. Foldable displays, in particular, are predicted to further expand the potential of information devices.

We are also proceeding with the practical application of TELeMetrics™, which remotely connects our company with our customers’ manufacturing site, thereby enabling remote maintenance, as well as remote support for equipment using AR smart glasses and material searches utilizing AI.

Furthermore, we are also systematically recruiting and training human resources to utilize data science in our business. In November 2020, we relocated our Sapporo office, a software development site, and established TEL Digital Design Square as our home base for DX activities. In addition to installing leading-edge facilities and adopting a hot-desking system to develop software technology, we will put effort into recruiting and training data scientists, data analysts and other human resources necessary for DX to utilize data science in our business.

Based on the belief that utilizing digital technology can contribute to everything from accelerating the speed of development, improving productivity and quality, and enhancing business efficiency to reforming workstyles, we are working on greater DX promotion.

Example Initiative

In the adjustment of film stress (target value: -100 to 0 MPa) using plasma-enhanced atomic layer deposition (PE-ALD), we used AI-based machine learning to consolidate and analyze past test data and optimize the process in order to overcome the inability of the previous method to achieve film stress requirements using engineers. As a result, we were able to not only resolve this issue but also contribute to reducing wafer consumption. By making use of AI as a member of the team, not bound together by conventional thinking and practices, engineers will be able to perform work with high added value.

Image of DX Usage

Promoting Digital Transformation (DX)

DX promotion, which is making waves across the global industrial world, is also becoming more prominent in the semiconductor and flat panel display (FPD) production equipments industries. Having positioned DX as an important part of the solution to the demand for further miniaturization and multi-layering in 2021, we formulated the TEL DX Vision of "a global company where all employees drive enterprise value creation sustainably through activities such as value addition and efficiency improvements by leveraging digital transformation." The two key objectives of this are to contribute to customers’ value creation in a range of settings from development to mass production and to raise capital efficiency in a range of settings from the product planning stage to manufacturing. We will achieve these two objectives by resolving high-level problems via a cycle of monitoring, analysis and prediction, control and autonomy.

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Our product lineup includes the Impressio™ and the Betelex™ FPD etch/ash systems, the Exceliner™ FPD coater/ash system, and the Exaline™ FPD coater/ash system. We have also released PICP™ Pro, a new plasma module for high-definition displays that achieves both yield improvements and mass production stability by reducing the generation of particles. The Exceliner, equipped with our original Air Floating Coater, permits higher throughput while maintaining excellent film uniformity and saving chemical costs. The Elius inkjet printing system can significantly reduce the amount of particles released into the air, and is also suited to production on large substrates. We are proceeding with development and sales of the Elius series ahead of the imminent era of large, high-definition OLED.

We will continue contributing to the further development of diverse display products, tackling effective technological innovation based on market needs such as improving productivity and yield and using energy and materials more efficiently.