Research and development

Research and development for the future

As lifestyles and business models undergo dramatic changes in the era of the IoT, it is anticipated that the use of semiconductors will expand in all industries, and there will be demands for even more advanced technologies. As electronics become even familiar for people, semiconductors become a larger part of everyday life. In readiness, Tokyo Electron (TEL) formulated and released the TEL Technology Vision 2030. TEL is continuously engaged in rigorous debate regarding technology for the future and TEL’s contribution, and is actively communicating the results of this within the company.

Development system

TEL attaches weight to promoting technology development and technology innovation for the next generations, and has built a system in which its Development & Production Divisions collaborate with Business Divisions to bring high-value-added products into the market in a timely fashion. In 2018, TEL established the Corporate Innovation Division, which strives to further strengthen process integration capabilities maximizing TEL’s strengths in deposition and etching technologies, based on its wide lineup of semiconductor production equipment. Under this new structure, TEL has been accelerating technological innovation as well as cross-functional development.

Front-loading

TEL is focusing on front-loading, investing resources (including technology, personnel, and money) in the early processes of product development. The company shares its technology roadmap with customers who aim for next-generation and next-next-generation research and development and beyond, and is engaged in development of the various technologies required for its realization. TEL proposes its unique technologies to promote on-site collaboration for early introduction of evaluation units at customers’ plants and research and development laboratories, aiming for acceleration and maximum efficiency of technology development and conversion to mass production equipment.

Medium-term goals (1)

Create strong next-generation products

Priority themes, Main activities:

- **Tackling technological innovation**
  - R&D for the future, front-loading, collaboration with consortia, IP management
  - Tackling technological innovation
  - Integrating analog and digital, leveraging AI technology, responding to developments in display
  - Environmental contribution of products
  - Products that contribute to a sustainable society, initiatives concerning environmental laws and regulations related to products

SDGs initiatives

- **Aim to build a more sustainable society by promoting further innovation through innovative technology**
- **Contribute to the reduction of environmental impact on a global level by providing products and services that are conscious of the environment**

SDGs initiatives:

- **R&D**
  - R&D for the future, front-loading, collaboration with consortia, IP management
- **Tackling technological innovation**
  - Integrating analog and digital, leveraging AI technology, responding to developments in display
  - Environmental contribution of products
  - Products that contribute to a sustainable society, initiatives concerning environmental laws and regulations related to products

Industry, innovation and infrastructure

Climate action

Sustainable Development Goals

- **Sharing of multi-generation technology roadmap with customers**
- **Promotion of early engagement**
- **Maximization of yield for customer devices and equipment operating rate from early stages of mass production, and also reduction of environmental impact**
- **Promotion of improvements in work efficiency and per person productivity, and further increase in investments into human resources and development**

Solution provider for all industries with connections to semiconductors

Solution provider for the semiconductor industry

Now

2030

Front-loading

- Business deployment utilizing the industry’s largest number of products delivered (69,000 units)
- TELAmetrics™ remote maintenance
- Predictive maintenance using machine learning

Advanced field solutions

Industry, innovation and infrastructure

Climate action

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**Intellectual property management**

In its intellectual property-related activities, TEL’s basic policy is to contribute to increased corporate revenues by supporting business activities through appropriate protection of intellectual property (IP). IP personnel assigned at R&D/manufacturing sites and headquarters 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. In 2018, in order to uphold the company’s worldwide advantage in the IP field, TEL maintained a global patent application rate of approximately 70% for the eighth consecutive year, and achieved high patent approval rates (83% in Japan and 85% in the United States). TEL is also increasing patent application in China in line with changes in market circumstances. To increase IP awareness, TEL continuously educates its engineers, who are the foundation of TEL’s R&D strategy, and in total around 4,200 engineers have become inventors. Additionally, because TEL often handles highly confidential information including technological information of its customers and collaborative partners, the company also focuses on confidential information management education.

**Collaborating with consortiums**

Along with enhancing its own research and development capabilities, TEL is also engaged in the development of cutting-edge technologies in collaboration with international and domestic consortiums. With bases including the United States, Belgium, and Singapore, TEL collaborates with device manufacturers worldwide and with global research institutes to promote research into next-generation semiconductor production technology. From 2018, TEL is participating in a global research hub developing next-generation AI hardware. In this consortium, TEL is mainly responsible for development that raises the added value of software, such as advanced control software, in addition to manufacturing technology for chips and devices capable of operating at high frequencies. The consortium, a research hub developing next-generation AI hardware, is one of multiple international consortia TEL is collaborating with to cooperate on the development of next-generation computing. It is also developing technology that mimics human neural functions, including resistive analog neuromorphic device, nonvolatile resistive random access memory, and so on. Leveraging its strengths in deposition and patterning technologies, TEL has initiated research efforts into new materials needed for semiconductors that will be the core of next-generation computing, such as neuromorphic devices, quantum computers, and displays. Tackling technological innovation

**Integrating analog and digital**

In the era of IoT, when a multitude of devices can connect to the internet, semiconductors are required to process massive amounts of data quickly and efficiently. At the same time, progress is taking place in the development of neuromorphic devices, inspired by human neural circuits. Computers used in data centers that use conventional architecture consume tens of kilowatts of power, while the human brain uses only about 20 W. Similarly, whereas the operating frequency of today’s semiconductor devices is 5 GHz, the human brain is believed to run at just a few tens of hertz. Neuromorphic devices utilize synaptic connections based on analog devices to replace the processing and memory functions, which had previously been only divided between the digital logic and memory of a conventional microprocessor. The aim is to achieve a higher degree of information processing with lower power consumption.

Furthermore, the development of neuromorphic devices requires an approach of integrating analog to digital. In addition to conventional pursuit of circuit miniaturization, development is underway of semiconductors that mimic human neural circuits, including resistive analog neuromorphic device, nonvolatile resistive random access memory, and so on. Leveraging its strengths in deposition and patterning technologies, TEL has initiated research efforts into new materials needed for semiconductors that will be the core of next-generation computing, such as neuromorphic devices, quantum computers, and displays. Tackling technological innovation

**Using AI technologies**

TEL is promoting the use of AI and striving to achieve highly stable equipment operation and greater efficiency in development activities. By monitoring the operating status of semiconductor production equipment in real-time, and using AI to analyze that data, TEL aims to improve equipment operation efficiency such as maintenance of equipment performance, achieving wafer process uniformity, and avoiding unexpected downtime. TEL’s specialized AI department, launched in 2017, plays a key role in the development of algorithms and other projects to use AI to analyze the vast volumes of data output from equipment. From 2018, the company has held AI workshops, aiming to share the latest technology trends and to boost internal collaboration, to achieve more efficient development activities.

**Addressing advancements in display**

Displays used in personal computers, televisions, and mobile devices have been constantly evolving, growing in size and resolution. Furthermore, in recent years, progress has also been made in the adoption of organic EL that is self-luminous and that offers superior contrast. Such cutting-edge display production is supported by photolithography technology to create minute electronic circuits on glass substrate. TEL develops, manufactures, and sells FPD coater/developer equipment and FPD dry etch system. In 2017, TEL launched a product compatible with production of the world’s largest glass substrate, the Generation 10.5 substrate (2,940 mm x 3,370 mm). FPD coaters/developers can coat and develop a light-sensitive material known as a photoresist with extreme uniformity. The air floating coater unit, which was developed independently by TEL and which was the world’s first to be used in mass production by TEL, simultaneously realizes stable glass substrate transfer, greater productivity, and improved uniformity. The FPD dry etch system etches various thin-film materials using a photore sist-drawn pattern as a mask. Important here is uniform processing in the surface of glass substrates, which are becoming increasingly bigger. TEL has independently developed devices capable of continuously changing resistance transformers.
Environmental contributions

Environmental risks and opportunities

The various issues related to the environment have an impact on our daily lives and on the business activities of companies. Physical risks, such as rising average global temperatures, strong winds, disasters, and water shortages caused by climate change and abnormal weather, heighten the risks to businesses, such as damage to assets, increased operating costs, and impacts on the supply chain. In terms of legal risks, tougher environmental laws and regulations require action at business sites and with products. At the same time, promoting environmental initiatives leads to more opportunities to provide outstanding environmentally friendly products, reductions in operating costs, and further improvements in corporate value. Based on the requirements of ISO 14001, Tokyo Electron (TEL) identified and analyzed internal and external issues in relation to the environment, namely, its relationship with the climate, air quality, and water quality. TEL also identified the environmental needs and expectations of customers, suppliers, governments, and employees, as well as the company’s compliance obligations. From this information, TEL has set the following as its risks and opportunities to address: (1) environmental management by reducing the environmental impact of its business activities, (2) compliance with applicable laws, and (3) enhancing product competitiveness with the environmental contribution of products.

CO₂ emissions across the value chain

TEL recognizes environmental impact throughout the value chain, and develops business activities that are conscious of reducing this impact. TEL aims to resolve environmental problems through leading technology and reliable services, in line with its environmental slogan "Technology for Eco Life."

- **Upstream**
  - Reductive CO₂ emissions from use of natural gas owned or controlled by TEL: 174 kilotons
  - Indirect CO₂ emissions from electricity use & gas use: 24 kilotons
  - Indirect CO₂ emissions from electricity use & fuel use: 150 kilotons
  - Upstream transportation and distribution: 139 kilotons

- **TEL**
  - Direct CO₂ emissions from electricity use & gas use: 6,014 kilotons
  - Emission footprint (per wafer) as compared with 2013: 9,873 kilotons

- **Downstream**
  - Direct CO₂ emissions from electricity use & gas use: 453 kilotons
  - Indirect CO₂ emissions from electricity use & gas use: 5,873 kilotons

The total of Scope 1 and Scope 2 of the TEL Group is 174 kilotons, while Scope 3 accounts for a total of 6,467 kilotons, which is approximately 97% of the total. TEL believes that it is particularly important to develop products with low CO₂ emissions during operation, as CO₂ emissions from the use of products sold amount to 5,873 kilotons, which is 88% of the overall total.

Medium- and long-term environmental goals

**Medium-term goals (2030)**

- Reduce per-wafer CO₂ emissions (as compared with 2013) by 20%.
- Reduce year-over-year energy consumption at each factory and office (moving average) by 1%.
- Reduce per-wafer CO₂ emissions (as compared with 2013) by 30%.

**Long-term goal (2050)**

As a leading corporation in environmental management, Tokyo Electron works actively to conserve the global environment. We strive to contribute to the development of a dream-inspiring society by proactively promoting the reduction of environmental burdens of both our products and facilities, and at the same time, providing revolutionary manufacturing technologies that effectively reduce the power consumption of electronic products.

Products that contribute to a sustainable society

Of the total CO₂ emissions from the value chain of TEL, emissions arising from product use account for 88% of its total CO₂ emissions. For this reason, TEL has made it a key corporate objective to promote environmentally friendly product design, and lower the energy consumption of its products. In fiscal year 2015, the company established a goal to reduce energy and pure water consumption by 10% by fiscal year 2019, using fiscal year 2014 consumption as the baseline. To achieve this goal, the company has worked to reduce energy use and improve overall throughput. As a result, in addition to achieving the goal for four models prior to fiscal year 2019, TEL achieved its goal for a further four models in the target fiscal year of 2019. Specifically, the company aimed for improved efficiency in Tactras™ Vigus™, plasma etch system for 300 mm wafer processing that offers high reliability and high productivity, managing to reduce energy consumption per wafer by 12%. In addition, the company also achieved above-target energy-saving results for the EXPEDIUS™ series batch cleaning system, NS3002D scrubber system, and CELLESTA™ series surface preparation system, including improved throughput and wafer-process optimization. From fiscal year 2020, TEL has set the new medium-term goal of “30% reduction by fiscal year 2031 in comparison with fiscal year 2014 for the key models of each business unit (30% or more reduction in CO₂ emissions when compared with equipment shipped in fiscal year 2014).” With this goal, the company endeavors to address not only energy and water as done conventionally, but also use of process gas and chemical substances, to reduce product footprint, volume, and weight, and the frequency of parts maintenance, while increasing the lifespan, and shortening the launch time of equipment, in order to incorporate its contribution to CO₂ reduction.

Initiatives for product environmental laws and regulations

In order to comply with each country’s environmental laws and regulations pertaining to products, TEL proactively collects information and takes appropriate action as required. An example of its efforts for EU REACH3 regulations is that the company investigates the presence of any substances of very high concern (SVHC) in articles, and discloses information appropriately. As for efforts for GHS requirements, TEL provides safety data sheets (SDS)4 when selling chemical goods. In fiscal year 2019, the company partially revised the environmental IT system introduced in fiscal year 2018 in order to continue to share information more efficiently with its supply chain. In addition, TEL has also continued to offer “web-based training for Product Environment Compliance” to all employees, providing a description of the frequently revised environmental laws and regulations and product compliance. The company also provides suppliers with information on the relevant environmental laws and regulations. TEL will continue to monitor each country’s environmental laws and regulations rapidly and strive to take appropriate action.

Biodiversity

In carrying out its business activities, the TEL Group has a not insignificant impact on biodiversity, and yet without the benefits yielded from biodiversity, the company could not sustain its activities. In recognition of this, the Group will develop a framework for promoting initiatives in an effort to conserve biodiversity.

Green procurement

TEL promotes green procurement, prioritizing the purchase of environmentally friendly parts, products and materials.

Logistics initiatives

As logistics activities have become more stringent in recent years and the demand for a lower impact on the environment rises, TEL has been promoting modal shifts5 to other means of transportation. Refers to switching the means of transportation from truck or aircraft to trains or water transport, such as rail or ship. In promoting initiatives for the environment, TEL will maintain close communication with all its stakeholders.

Environmental communication

TEL’s environmental policy requires that, based on a shared understanding with a broad range of stakeholders, the company promotes cooperative partnerships with them, and it takes appropriate steps to live up to their expectations. In promoting initiatives for the environment, TEL will maintain close communication with all its stakeholders.