RESEARCH AND DEVELOPMENT/INTELLECTUAL PROPERTY

RESEARCH AND DEVELOPMENT

The semiconductor industry will continue to expand.

Electronic devices pervade every corner of the world, and the number of semiconductors in each device continues to increase. In the future, the reach of semiconductors will not be limited to computers and telecommunications but will expand to healthcare, agriculture and myriad other applications. Already a core component supporting modern society, semiconductors will take on an even large role as their applications expand.

Technology is driving the growth in the semiconductor industry. Speed is increasingly important in achieving technology development. In this ultra-competitive era, business opportunities are lost if technology—even superior technology—misses its window. Tokyo Electron establishes development sites close to the customers and builds collaborative relations to accelerate technology commercialization and ensure that the right technology is supplied to customers exactly when they need it.

The development of cutting-edge technology, commonly called "high technology," requires the integration of expert knowledge in a variety of fields to invent entirely new technical concepts. The proactive use of open innovation to gain outside knowledge has become increasingly important as a result. In April 2012, Tokyo Electron relocated its corporate R&D division, which is tasked with developing future technologies, from Yamanashi to the newly established TEL Technology Center Tsukuba, in Ibaraki Prefecture (Japan). Tsukuba has been a magnet for R&D organizations, and we will increase collaborative research efforts with these outside organizations on new semiconductor materials, photovoltaic (PV) power generation, and other high-tech fields to nurture new seed technologies.

Over the next five to ten years, the research and development activities at Tsukuba will crystallize into new products which will become the foundation of Tokyo Electron's future growth.

Chip Scaling and 3DI Packaging Initiatives

The value of semiconductors is rooted in scaling, or miniaturization.

Tokyo Electron has always been at the cutting edge of lithography technology innovation. We are developing resist coatings and development technology for extreme ultraviolet (EUV) lithography, a next-generation lithography technology, while continuing to enhance our multiple patterning technologies.

Additionally, we have begun intensive collaboration with universities and research consortiums on the development of directed self-assembly (DSA) technology in which patterns are automatically formed using a substance's chemical attributes, eliminating the need for exposure. Through these efforts, we have built a structure to ensure we can fully support whatever lithography technology takes hold in the marketplace.

In the area of three-dimensional interconnect (3DI) packaging, in which multiple silicon chips are stacked to increase performance, we are pursuing commercialization of high-aspect-ratio silicon etch systems and proprietary polyimide dielectric film deposition systems to support through-silicon via (TSV) technology. These efforts will prepare Tokyo Electron for the full-fledged arrival of 3DI packaging technology.

Developing Low-Power-Consuming Semiconductors

In recent years, semiconductors' power consumption has become a major issue. With an astounding number of miniaturized elements packed onto a small silicon chip, the chip's power consumption rises dramatically and a significant amount of heat is generated. At datacenters where large numbers of servers and other electronic equipment are concentrated, it is amazing to find that cooling the electronic equipment requires more power than the equipment itself. It's not an exaggeration to state that semiconductors will not advance unless their power consumption is reduced. Amid this conundrum, important technological innovations are being made with the goal of reducing the power consumption of semiconductors.

One approach to lower power consumption involves changing the structure and materials of transistors. Intel Corporation announced the introduction of the world's first 22nm-node three-dimensional transistor (Tri-gate FET) which promises both low operating voltage and high performance. Tokyo Electron is supporting the device manufacturers of these kinds of three-dimensional transistors with the development of new products which incorporate proprietary low-damage plasma technologies needed in the transistor manufacturing process.

TEL Technology Center Tsukuba — Our New R&D Base
We have established a new R&D base in the city of Tsukuba, the world's pre-eminent academic town. The center is engaged in research on PV manufacturing technology, semiconductor manufacturing technology, and a variety of new seeds technology.

In other areas of technological innovation for transistors, indium gallium arsenide (InGaAs) and germanium (Ge) are among the new materials being adopted. Considering silicon's long history as the core semiconductor material, its replacement with InGaAs and Ge represents a major innovation. Many of the current semiconductor manufacturing processes, including epitaxial growth, surface processing, and gate dielectric film formation, require innovation. Tokyo Electron views the changes in the industry as new opportunities. We are proactively responding to recent innovations in semiconductor materials with the development of new equipment and processes.

Another approach to reducing power consumption is the development of nonvolatile memory based on new scientific principles and materials. Semiconductor manufacturers are racing to develop spin transfer torque-magnetoresistive random access memory (STT-MRAM), a promising technology seen as the possible next-generation memory device. STT-MRAM records data in terms of 1s and 0s by changing the direction of the magnetic field. Since no electricity is used to store data, STT-MRAM device can operate using less than half the energy consumed by today's DRAM and SRAM devices. We are collaborating with Tohoku University, the world's leading technology research organization in this field, to develop cutting-edge manufacturing technology for STT-MRAM to ensure that we are fully prepared for the advent of the technology in the marketplace.

Addressing Environment and Energy-related Issues

The Tokyo Electron Group is leveraging all of its resources to address the global issues of the environment and energy.

PV power generation is widely considered to be the green energy solution of the future. Though the photovoltaic cell industry continues to experience a harsh business environment due to oversupply and plunging panel prices, significant medium- to long-term industry growth is expected. Tokyo Electron is accelerating the development of thin-film silicon PV, considered optimal for large-scale power generation due to lower manufacturing costs gained from reduced silicon usage, with the goal of enhancing conversion efficiency. PV-related R&D will be consolidated at the newly established TEL Technology Center Tsukuba. The center will be engaged in research and development on PV manufacturing technology using different materials besides thin-film silicon, including new chemical compounds and organic materials.

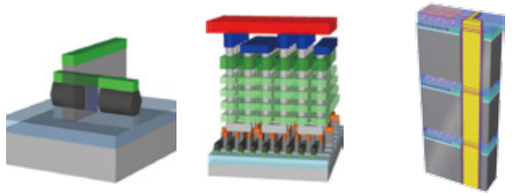
Exploring New Fields

Tokyo Electron nurtures new fields of research in order to ensure the company's sustainable growth.

One example is the development of manufacturing technology for printed electronics, a field attracting significant attention. Innovative printed electronics technologies utilizing patterning and deposition have the potential to greatly lower display panel manufacturing costs. Tokyo Electron is a member of the Japan Advanced Printed Electronics Technology Research Association (JAPERA) and monitors the development of applicable products for insights on promising new technologies.

We also have our sights on life sciences and other fields with strong growth potential. The boundaries of our technological innovation are not limited to miniaturization and other semiconductor manufacturing technologies. Instead, we are pursuing applications of our technology to fields outside semiconductor manufacturing and taking initiatives to create new industries and business areas.

Evolution of Semiconductors



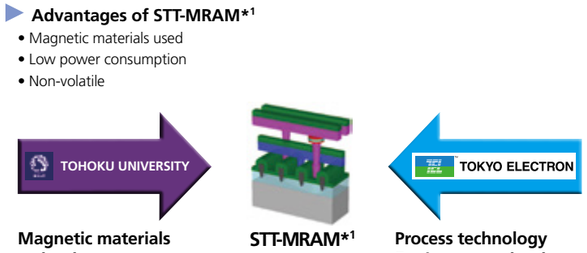
3D Transistor (Logic FinFET)
New transistor structure that enables both lower power consumption and higher device performance.

3D NAND
New NAND flash memory with vertically stacked memory cells realizing higher capacity.

3DI TSV
Through-silicon via interconnection technology for three dimensional chip stack achieving higher performance.

Zoom

Joint Development of Next-generation Memory with Tohoku University



Magnetic materials technology
Device design technology

STT-MRAM*1

Process technology
Equipment technology

*1 STT-MRAM: Spin Transfer Torque-Magnetoresistive Random Access Memory

Zoom