Semiconductor Device Manufacturing & Inspection Equipment

1 Semiconductor Device Fabrication and Diverse User Needs

Information systems have continually evolved for realizing a data-driven society. Today's information systems are composed of Internet of Things (IoT) edge devices, servers on edge nodes near these devices, and in the cloud. Examples of IoT edge devices include smartphones, home appliances, vehicles, industrial equipment, and semiconductor fabrication equipment.

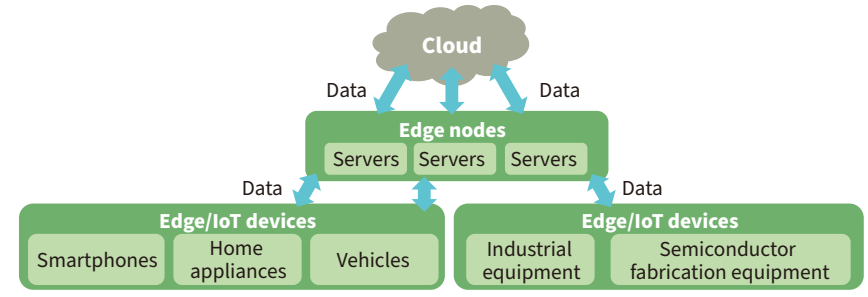
Semiconductor devices are the core components of information systems and are becoming diverse. Cutting-edge semiconductor devices for higher speed or larger capacity are evolving with more complexities, smaller dimensions, or more layers in the structure. Manufacturing these cutting-edge devices requires etching and measurement processes with higher levels of precision and speed than ever before. Fabrication facilities that mass-produce these devices also require predictive maintenance of equipment for higher utilization rates and productivity. Semiconductor devices for automotive or industrial uses require a higher level of reliability that calls for new three-dimensional (3D) shape control.

Hitachi will continue to provide solutions for diverse user needs.

(Hitachi High-Tech Corporation)

2 AI-based Predictive Diagnostic System for Improving Plasma Etching Equipment Availability

As semiconductor fabrication equipment suppliers, companies need to meet demands for cutting-edge device development from device manufacturers, along with demands for higher productivity from mass-production plants. Hitachi High-Tech Corporation has developed a prognostics and health management (PHM) system that uses etching equipment data. It is planning to start a new



Cutting-edge logic devices

Year	2019	2020	2021	2022	2023	2024	2025
Technology node (nm)	7 to 5			5 to 3		3 to 2.1	
Gate pitch (nm)	48			45		42	
Metal pitch (nm)	30			24		21	
Transistor structure	FinFET (n, p, Gate, Fin)					GAA FET (n, p, Gate, Nanosheet)	

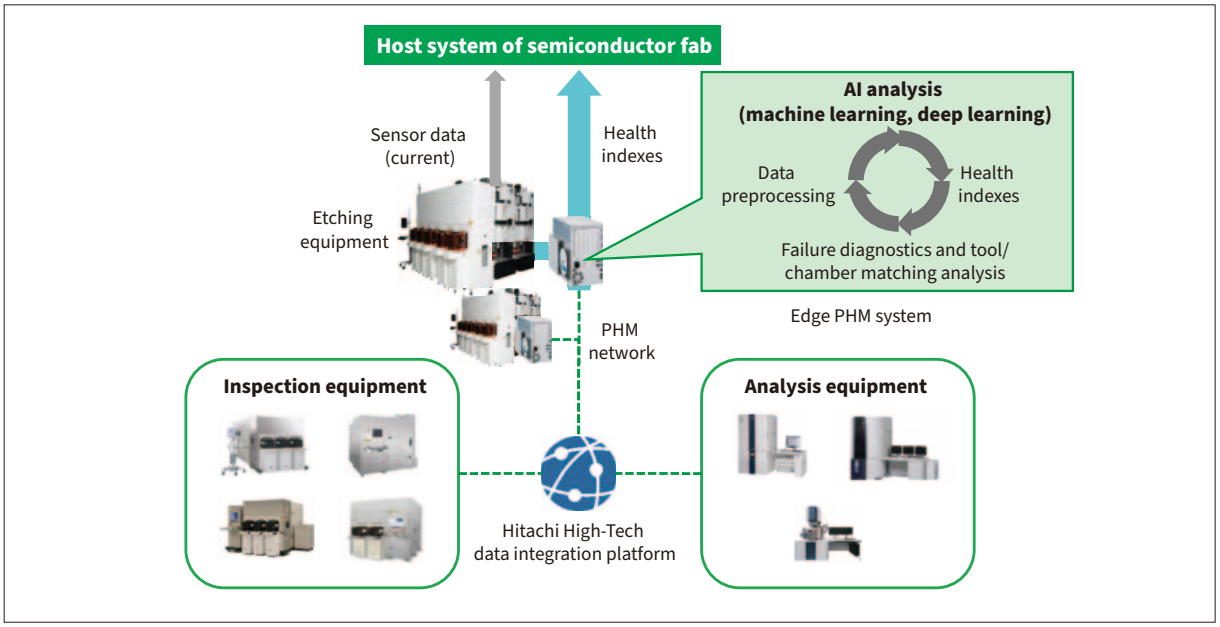
Memory devices

Year	2019	2020	2021	2022	2023	2024	2025
DRAM Technology node (nm)	up to 17			up to 15		less than 13	
3D NAND Number of layers	up to 128			up to 192		more than 200	

(Estimated by Hitachi High-Tech Corporation from sources such as IRDS 2020)

FinFET: fin field-effect transistor GAAFET: gate-all-around field-effect transistor DRAM: dynamic random-access memory

1 Evolution of information systems and semiconductor devices



2 PHM system configuration

service business area designed to improve semiconductor fabrication productivity.

The PHM system is equipped with algorithms created using cutting-edge artificial intelligence (AI) technology in the etching tool, and can provide predictive diagnostic technology combined with the semiconductor equipment supplier's unique equipment-domain knowledge. A PHM network can also be created in customers' fabs, making it possible to provide efficient solutions to issues caused by tool/chamber matching issues in mass-production semiconductor fabs. For each device node in semiconductor device development, which consists of research and development, pilot, and mass-production phases, it is necessary to rapidly solve issues in semiconductor fab, so the PHM system was designed for easy implementation of predictive diagnostic applications developed by collaborative creation with customers.

Hitachi High-Tech intends to provide new solutions by connecting the PHM system to the Hitachi High-Tech data integration platform to bring together inspection and analysis equipment data and to construct a proprietary ecosystem.

(Hitachi High-Tech Corporation)

3 High-resolution FEB CD-SEM CG7300 for Developing or Mass-producing Cutting-edge Semiconductor Devices

Leading device manufacturers such as TSMC, Samsung, and Intel[*1] have introduced new extreme ultraviolet (EUV)[*2] lithography technology that enables high-precision processing and enhanced manufacturing for shrinking semiconductor devices. The technology is geared toward applications for sub-10-nm node semiconductor device manufacturing processes used for devices such as high-end processors, mobile processors, and memory.

Hitachi High-Tech has developed a new field emission beam (FEB) critical dimension-scanning electron microscope (CD-SEM)[*3] CG7300 to suit market trends. The CG7300 satisfies the need for more demanding ultra-high-precision metrology by enabling the atomic-level measurement essential for more reliable process control and mass-production stabilization.

The CG7300 improves quality control by offering a wide range of ultra-high-precision metrologies such as

3 High-resolution FEB CD-SEM CG7300 for developing or mass-producing cutting-edge semiconductor devices

4 Model CT1000 3D SEM for defect shape evaluation

critical dimension (CD)[*4] measurement supporting EUV mass-production generation, along with roughness[*5] measurement and low-damage measurement. It also improves productivity with high throughput, and furthermore provides Hitachi's original technology for advanced "tool to tool matching control" using atomic-level measurement values. Those performance and technology features enable advanced process control that can contribute to improving customer benefits.

Hitachi High-Tech's CD-SEMs have been selling for more than 30 years and now have a 70% share of the worldwide market. They have become the de facto standard in the field of metrology, creating and leading the market for electron beam metrology as a driving force behind the semiconductor manufacturing industry's evolution.

(Hitachi High-Tech Corporation)

*1 TSMC: One of the largest semiconductor foundries in the world. Samsung: The core semiconductor manufacturer of the Samsung Group. Intel: The world's largest processor device manufacturer.
*2 An extreme ultraviolet light source with a wavelength of 13.5 nm.
*3 A scanning electron microscope (SEM) specialized for measuring microminiature circuit patterns on semiconductor wafers. A crucial measuring device for yield management. Used in inspection processes on semiconductor device development lines and mass production lines.
*4 Dimension for critical pattern of electrical circuit.
*5 Local fluctuation of the pattern edge position.

4 CT1000: 3D SEM for Defect Shape Evaluation to Help to Improve the Quality of IoT/Onboard Devices

The recent growth of the electric vehicles market and release of fifth generation (5G) smartphones have created a need for reliable, high-quality IoT and onboard devices with 3D structures. Device manufacturers have responded to this need by starting to actively use a total inspection methodology for selecting non-defective products, which has not been used previously in manufacturing inspection or measurement processes. This is a paradigm switch that has created a growing need for in-line shape observation SEMs that can identify 3D device structures on a wafer and can review defects generated during pattern formation.

Hitachi High-Tech has developed the CT1000 – a 3D SEM for evaluating defect shapes to meet these demands. The CT1000 can automatically load wafers up to 200 mm in size. It moves precisely to the critical pattern position or the defect position based on the location provided by the defect inspection tools. 3D SEM observation can then be performed using a tilting sample stage. In addition, the CT1000 has an energy-dispersive X-ray spectrometer (EDS) that can be used to identify elements contained in the sample.

Hitachi High-Tech is planning to work on automating the processes to observe pattern shapes and defects, helping to ensure device reliability and shorten development turnaround time (TAT).

(Hitachi High-Tech Corporation)