

Development of Three-Dimensional Non-Destructive Measurement Techniques for Advanced Logic Semiconductors Using High-Brilliance Synchrotron Radiation

Participants

Semiconductor and Quantum device Analysis Technology research association (SQAT)

Overview

In advanced logic semiconductors, which are gaining importance from the perspective of economic security, development is underway on logic devices employing Gate-All-Around (GAA) transistors with vertically stacked structures. As device scaling progresses, further improvements in integration density and performance of GAA transistors, as well as the introduction and optimization of backside power delivery networks (BSPDN), are expected. Consequently, the manufacturing processes are becoming increasingly complex, raising the difficulty of development. Key metrology challenges include strain measurement, evaluation of gate dielectric quality, and three-dimensional structural analysis of interconnects. This project aims to develop non-destructive measurement and analysis techniques using high-brilliance X-rays at the large-scale synchrotron radiation facility SPring-8 to address these three metrology needs.

Research and Development

Three new X-ray analytical techniques utilizing the high-brilliance X-rays from the large-scale synchrotron radiation facility SPring-8 will be developed:

- 1) Nano X-ray diffraction analysis for strain evaluation
- 2) High-resolution HAXPES (hard x-ray photoelectron spectroscopy) for gate dielectric quality assessment
- 3) X-ray ptychographic microscopy for shape and composition analysis of fine interconnects

By utilizing the excellent penetration capability of hard X-rays, internal information can be extracted. In collaboration with research institutions, the project will also develop key enabling technologies necessary to realize the above techniques, including X-ray optics, high dynamic range X-ray imaging detectors, high-speed data analysis using dedicated computing systems, and ultra-high-precision X-ray focusing mirrors.

Collaborating institutions: RIKEN, Osaka University

SPring-8

The primary site for this project, providing high-brilliance hard X-rays with excellent penetration capability.



Methodologies of the three analytical techniques

High-brilliance X-rays from SPring-8 are focused into a small spot using X-ray focusing mirrors, and Bragg-diffracted X-rays, emitted photoelectrons, and coherently diffracted X-rays are measured.

