Development of Next-Generation Semiconductor Process Technologies for EUV and BEUV under Japan's "K Program" by JST

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Japan launched the "K Program" in 2022 as a national strategic initiative to strengthen economic security by securing critical technologies while sustaining industrial competitiveness. Within this framework, JST has initiated approximately 20 large-scale R&D projects, among which the Next-Generation Semiconductor Process Technology project, launched in April 2025, addresses the long-term sustainability of lithography by focusing on future light-source technologies.

This five-year project positions light sources as the central bottleneck and opportunity in the evolution of EUV and BEUV semiconductor manufacturing. Two complementary and strategically distinct approaches are pursued: high-efficiency solid-state drive lasers to extend and stabilize current EUV exposure systems, and free-electron lasers as a potential breakthrough light source capable of overcoming fundamental power, coherence, and scalability limits of plasma-based EUV sources.

To translate light-source innovation into manufacturable systems, the project simultaneously advances enabling technologies, including large-diameter high-precision mirror fabrication and coating, BEUV multilayer reflective coatings, high-sensitivity and high-resolution photoresists, and nonlinear optical materials for coherent light generation at wavelengths around 170 nm. These efforts are designed to form an integrated technology roadmap rather than isolated component developments.

By strategically linking laser science, accelerator-based FEL technology, and optical system engineering, the project aims to provide a credible pathway toward beyond-EUV lithography. This presentation outlines the project's strategic vision, technical roadmap, and early progress, with particular emphasis on the role of advanced light sources in shaping the future of semiconductor manufacturing.

Junji Yumoto received his Doctor of Engineering degree from Keio University in 1984 and began his career at Nippon Telegraph and Telephone Co. (NTT). He held several leadership roles at NTT, including Director of NTT Basic Research Laboratories and Director of NTT Photonics Laboratories, and later served as President of NEL America, Inc. based in New Jersey (now NTT Devices America, Inc.). In 2014, he was appointed Professor at the University of Tokyo, where he also served as Director of the Institute for Photon Science and Technology. Since 2021, he has been Emeritus Professor and Project Professor at the University of Tokyo, and currently serves as Program Director of the JST Program for the Development of Next-Generation Semiconductor Process Technologies.