Fundamental Research to Solve the EUV Technical Issues and Future Prospect for EUVL toward Advanced Devices Fabrication

Takeo Watanabe

Center for EUVL, Laboratory of Advanced Science and Technology for Industry, University of Hyogo

ABSTRACT

Extreme ultraviolet lithography (EUVL) started to use in the production of 7-nm-node-semiconductor devices in 2019. In 2020, EUVL started to use in high volume manufacturing of 5-nm-node-semiconductor devices for smart phones. The International Roadmap of Devices and Systems (IRDS) announced the semiconductor nanofabrication using EUVL will continue to 2028. The technical issues of EUVL toward 1.5 nm node are 1) resist technology, 2) mask inspection, 3) EUV light source with high power and stability.

Since 1995, EUV R&D has been started at the middle size NewSUBARU synchrotron light source of University of Hyogo, which is the largest synchrotron facility operated by university in Japan. Up to now, many significant technology research and development in EUV lithography were done by our research group. The research activities for resolving EUVL technical issues will be presented for the wide range technologies including resist, mask, pellicle, optical element evaluation, and so on. For the resist, it is including that the sensitivity under EUV and OoB exposure, outgassing, in-situ contamination growth, patterning using EUV-IL, chemical reaction analysis using synchrotron, and so on. The most significant issue in EUV resist is to achieve low LWR. And to achieve it, the spatial distribution of the chemical contents of EUV resist should be uniform. Thus, it is introduced that the soft X-ray resonant scattering method in transmission mode to measure the chemical contents spatial distribution in a EUV resist film. In addition, preventing from the pattern collapse is necessary to achieve high resolution, the adhesion control is needed for the fine pattern achievement. Thus, it is introduced that the layer analysis method in EUV resist film using the soft X-ray resonant scattering method in transmission mode. For the mask, it is including that the defect inspection using bright field EUV microscope and coherent EUV scatterometry microscope, outgassing, multilayer reflectivity measurement using EUV and OoB lights, material stability under high power EUV light in hydrogen and water vapor atmosphere. In addition, for the collector mirror reflectivity measurement in the significant usage for EUV LPP light source, the large reflectometer is presented.

In addition, the advanced lithography for the future quantum devices fabrication will be discussed.

BIOGRAPHY

Takeo Watanabe received his Ph.D. from Osaka City University in 1990. He is dean of Laboratory of Advanced Science and Technology for Industry, Director of Center for EUV, Full Professor, at University of Hyogo. He is an expert of the EUV lithographic technology, including optics, exposure tool, mask, and resist technologies. He has authored over 200 technical papers, and has many patents related to EUV lithography.

He is international affair, the organizing and program committee members, of the International Conference of Photopolymer Science and Technology (ICPST). He is also Chair of organizing committee of the International Conference of Photomask Japan. And he is a program committee member of the International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication (EIPBN).