The current status and difficulties in manufacturing multilayer mirrors for BEUV lithography

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As a strategy to advance the miniaturization of semiconductor circuit patterns using reduction projection exposure system, progress has been made in increasing the Numerical Aperture (NA) and shortening the exposure wavelength. Beyond-EUV (BEUV) with half of a wavelength that of the current state-of-the-art exposure wavelength of 13.5nm EUV light is under consideration. Multilayer mirrors with a reflection peak at a wavelength of 6.x nm have achieved a high reflectivity of 64%[1], elevating expectations for BEUV.

The 6.x nm wavelength multilayer mirrors had reflection bandwidths (FWHM) are an order of magnitude narrower than the bandwidth of the EUV multilayer mirror at a wavelength of 13.5nm. This leads to the problem that only a small portion of the BEUV light emitted by the plasma light source, can be reflected by the BEUV multilayers, resulting in significant loss of light. However, for the ERL-FEL light source, the bandwidth of BEUV light source matches the reflection bandwidth of the 6.x nm multilayers, suggesting efficient utilization of the light.[2]

For the BEUVL exposure system, there are challenges related to the matching of reflectance peak among multiple multilayer mirrors, the alignment with the incident angle bandwidth on the reflection mask and projection optical system mirrors. It is crucial to consider system optimization when establishing BEUVL. In this presentation, I will introduce examples of calculations and actual measurements for BEUV multilayer mirrors and the issues regarding the incident/reflection angle widths for BEUV multilayer mirros.

References

1. D. S. Kuznetsov, A. E. Yakshin, J. M. Strum, R. W. E. van de Kruijs, E. Louis, and F. Bijkerk, “High-reflectance La/B-based multilayer mirror for 6.x nm wavelength”, Opt. Lett. 2015, 40, 3778-3781
2. H. Kawata, N. Nakamura, H. Sakai, R. Kato, and R. Hajima, “High power light source for future extreme ultraviolet lithography based on energy-recovery linac free-electron laser”, Micro/Nanopattern. Mater. Metrol., 21 (2) 021210-1 (2023)

Biography

Hisataka Takenaka is a director of TOYAMA Co., Ltd. and a fellow member of The Japan Society of Applied Physics. He received his PhD from the Kwansei Gakuin University, Hyogo, studying the phase transition mechanism of ferroelectric crystals. After his PhD, he joined NTT (the Nippon Telegraph and Telephone Public Corporation, now NTT Corporation) in 1979, where he developed soft x-ray reduction lithography using multilayer mirrors, now called EUVL, with Dr. Hiroo Kinoshita and other colleagues. In 1996, he moved to NTT Advanced Technology company where he launched EUV multilayer mirror business. He also developed some kinds of multilayers and some X-ray focusing devices. In 2012, he joined TOYAMA Co., Ltd. to develop various systems that use synchrotron radiation and laser light.