DEBRIS-FREE EUV SOURCE FOR AT-WAVELENGTH METROLOGY

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Parallel to the development and optimization of high-power EUV sources for lithography, the realization of low-cost EUV sources for at-wavelength metrology is strongly required. These sources are important tools for the characterization of EUV mirrors and masks, for the determination of thin film transmission (EUV filters), for research on resist materials, and for the calibration of EUV detectors. Apart from the very expensive synchrotron facilities, EUV sources for metrology are presently based on laser- or discharge-produced plasmas. Besides a complex setup and high running costs, these sources operate at a relatively low repetition rate, exhibit considerable temporal and spatial fluctuations, and always require techniques for debris mitigation.

Fig. 1. Photograph of the EUV tube.

Usually it is overlooked that one can produce EUV radiation directly from solid targets avoiding all these plasma-related drawbacks. This can be done by using electron-induced characteristic emission from solids. The electron-based EUV source can be considered as an analog to a conventional x-ray tube [1]. Electrons are generated by a tungsten filament, accelerated in a high-voltage electric field toward an anode, and focused onto a low-Z solid target which allows the generation of characteristic emission in the EUV spectral range. This radiation is produced due to electron-impact ionization (excitation) of atomic inner shells, which is followed by radiative decay. As an example the K_α line of beryllium ($Z = 4$) and the L-shell radiation of silicon ($Z = 14$) are located at 11.4 and 13.5 nm, respectively. Therefore, electron-induced emission from these materials (especially from silicon) is of high practical importance for EUV-related applications. The EUV source operating on this mechanism ("EUV tube") fulfills practically all the requirements to a metrology source: stable, long-term, and debris-free operation; compact, low-cost, and user-friendly setup; well-defined, "easy-to-calibrate", and controllable output.

In this presentation, we will report on a novel compact electron-based EUV source for in situ metrology (see Fig. 1 for a photograph). The source is debris-free, has excellent long-term stability, and very low running costs. The characteristics of this source like spectral properties, power, source size, and stability will be presented. Different applications in the field of at-wavelength metrology will be discussed. Results of EUV mirror reflectometry will be demonstrated and compared with measurements obtained at synchrotron and plasma-based facilities.

References:

[1] A. Egbert et al., J. Microlith., Microfab., Microsyst. **2**, 136 (2003).