GUEST EDITORIAL

EXTREME-ULTRAVIOLET INTERFERENCE LITHOGRAPHY

The development of extreme-ultraviolet lithography (EUVL) continues at an accelerating pace. Today, industry is looking at EUVL for the 16-nm node and below. Optics, sources, masks, and resist materials are all objects of intense research. Photoresists are a gating component of EUVL, because of the conflicting requirements of high sensitivity, high resolution, and low line-edge roughness. This development of advanced imaging materials is hampered by the scarcity of EUVL exposure systems and by limited access to these tools. There is a need for alternative exposure systems where novel materials can be tested and characterized quickly, economically, and without fear of contamination of the optics. Interferometric lithography (IL) is such a technique: in its simplest form, two coherent beams interfere to form a high-density fringe pattern that exposes the resist material. The uniformity, large area, and simplicity of operation make this fringe pattern ideal for the study of resist materials; in fact, several systems have been built for ArF lithography, including immersion. The extension of interferometric lithography to the EUV region is a natural technology evolution and makes high-resolution, simple, and fast-exposure systems available to the general research community. These exposure tools, based on the use of diffractive optics in various mounts, have shown patterning ability to the 10-nm region. Systems using two, three, and four beams have been demonstrated. Holographic lithography at EUV wavelengths has been proposed and demonstrated. Finally, we would like to point out that EUV-IL's freedom from cumbersome reflective optics makes it easily extensible to wavelengths shorter than the canonical 13.4 nm of EUVL. Thus, using synchrotrons or novel plasma sources in combination with 4× demagnification setups, EUV-IL will provide patterning ability in the 4- to 5-nm range, and even below.

This special section of JM^3 is dedicated to the presentation of the most recent developments in EUV-IL by leading research groups. These six articles span the range from the novel type of highly coherent EUV sources that are ideal for interferometry and lithography, to photoresist properties. Levine et al. discuss a cascaded interferometer for synchrotron applications. Jiang et al. present a detailed engineering study of image formation in EUV-IL and discuss the advantages and limitations from an optical point of view, including the results from 4× demagnification setups. The authors also discuss a method to explore EUV-IL imaging with controlled image contrast, i.e., with variable fringe visibility. The paper by Auzelyte et al. reviews the extensive activity at the synchrotron-based Swiss Light Source. Gronheid and Leeson present a review of requirements and performance of photoresist materials tailored for EUV, which is an excellent demonstration of the utility of EUV-IL in materials development. Wachulak et al. present recent results in the area of laboratory EUV sources and lasers. Finally, Smith presents a discussion of novel types of interferometers specifically designed for compact nonsynchrotron sources.

Clearly, much remains to be done before EUV becomes an acceptable manufacturing lithographic technique. As mentioned above, there are very few EUV exposure systems in the world, and these have restricted access. EUV-IL, on the other hand, is generally implemented in open-access laboratories, and thus can support a much broader community in the development of the necessary materials and techniques for the region extending to 10 nm and below. It is our hope that the results presented in the papers collected here will stimulate further development and help accelerate the introduction of EUVL in the mainstream of lithography.

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Guest Editor