Linewidth uniformity in Lloyd's mirror interference lithography systems

Thomas B. O'Reilly*, Henry I. Smith
NanoStructures Laboratory, Research Laboratory of Electronics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139

In interference lithography (IL), good control of feature size (grating linewidth for instance) is an important aspect of process control for many applications. Methods to characterize resist response to changes in exposure dose and dose modulation have been previously described [1, 2], and are useful for both process control and to characterize resist performance. In addition to understanding resist behavior, it is necessary to understand how the characteristics of the IL system affect the resulting pattern.

This paper considers one of the simplest types of IL system, the Lloyd's mirror, illustrated in Figure 1, in which light from a laser is spatially filtered, striking both the substrate and a mirror perpendicular to the substrate. Interference between the light from the source and its mirror image forms a grating pattern that is recorded on the substrate. While this type of system is easy to construct and use, the exposure dose and modulation both vary across the exposure area, being highest at the center of the incident beam (ideally located where the plane of the mirror intersects the substrate). This spatial variation in dose and modulation causes the linewidth to vary across the exposure area, and can also limit the area that can be exposed successfully. Additionally, light scattered from dust particles, or defects in the mirror, referred to as coherent noise, can significantly affect the results.

An analytical model of the way dose and modulation vary with position in a Lloyd's mirror system is combined with experimentally determined resist characteristics to model how linewidth varies across the exposure area. Additionally, the model can be used to determine the size of the area that can be successfully exposed under various conditions, and how changes in the configuration of the system would affect performance. The problem of coherent noise is also considered to determine the exposure conditions under which it will cause problems.

References:

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2. A. Bourov, S. A. Robertson, B. W. Smith, M. A. Slocum, E. C. Piscani, Proc. SPIE 6154, (2006)

* Presenting author, tbo@nano.mit.edu, 77 Massachusetts Avenue, Room 36-213, Cambridge, MA 02139

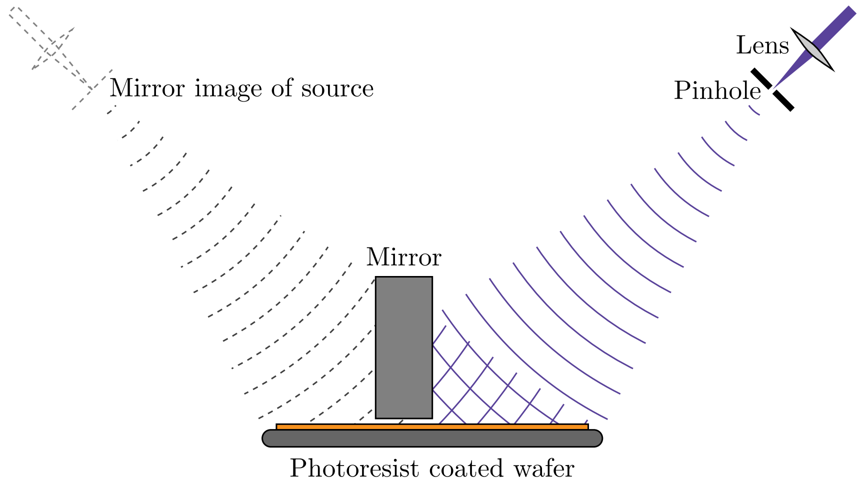

Figure 1. Diagram of Lloyd's mirror IL system. Light from a laser is spatially filtered and directed toward a photosensitive substrate. A mirror perpendicular to the substrate creates a mirror image of the source, and the resulting interference forms a standing wave. In this configuration the result is a grating pattern. Through the use of multiple exposures, it is possible to write grids or other, more elaborate patterns.