Dual-wavelength Interference Lithography

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Absorbance-modulation optical lithography (AMOL) provides a means of surpassing the diffraction limit in optical lithography [1]. In brief, an absorbance-modulation layer, composed of photochromic molecules that can be switched between two isomeric states, A and B, using light of two different wavelengths, λ_1 and λ_2, is placed on top of a photoresist film. When illuminated simultaneously with λ_1, in the form of a normal focal spot, and λ_2, in the form of a donut pattern with a central null, a deep-subwavelength aperture can be formed in the photochromic layer, through which the underlying photoresist can be exposed by λ_1. We have applied the AMOL concept to interference lithography by developing a dual-wavelength system (DWIL) with which to test photochromic dyes and photoresists for use with AMOL, and also to provide a means of achieving sub-100nm period interference lithography with a relatively simple system and an UV or blue exposure wavelength, such as 351 nm or 405 nm.

The DWIL system forms two parallel standing wave patterns of the same period, 180° degrees out of phase, as illustrated in Figure 1. Simultaneous exposure to the two standing wave patterns effectively forms subwavelength apertures, which narrows and sharpens the exposure dose distribution compared to the sinsoidal distribution that results from a conventional IL exposure. The sharper dose distribution makes it possible to expose multiple sets of lines by shifting the fringes on the substrate, which can be done with fringe-locking electronics. For instance, four exposures could be performed, shifting the phase of the fringes by 90° after each exposure, reducing the period of the pattern by a factor of four. The number of exposures that can be performed before the resist no longer resolves distinct lines depends on the materials used, making a system to test the performance of dye and resist systems critical to the development of AMOL technology. This paper presents the design of the DWIL system, including the methods used to align and lock the two sets of fringes together, as well as exposure results.

[1] Rajesh Menon and Henry I. Smith, "Absorbance-modulation optical lithography," J. Opt. Soc. Am. A **23**, 2290-2294 (2006)

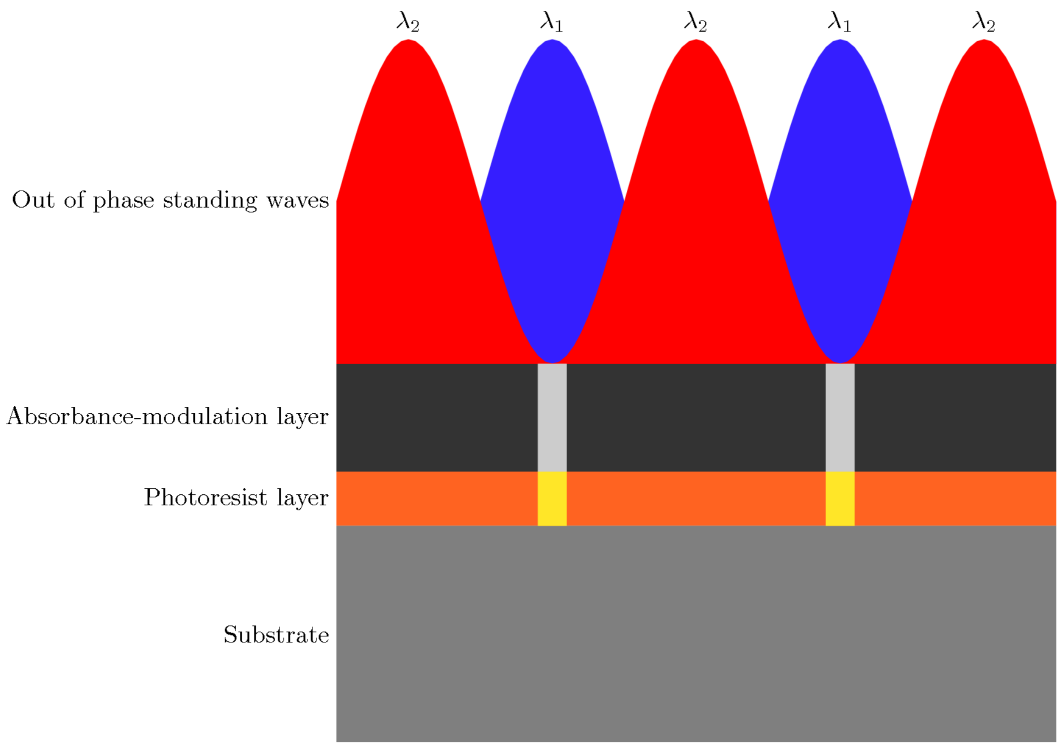

Figure 1. Schematic of dual wavelength IL exposure using an absorbance-modulation layer. Standing waves are formed in two different wavelengths, λ_1 (shown in blue) and λ_2 (shown in red). The photoresist is sensitive to λ_1, but not to λ_2. The interaction of the two standing-wave patterns results in narrow transparent regions in the AM layer (shown in light grey) at the locations of the peaks of the exposing wavelength, which narrows the exposed regions in a way that makes it possible to do multiple exposures by shifting the fringes on the substrate.