Increased Process Latitude in Absorbance-Modulated Lithography via Integration of a Plasmonic Reflector

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The resolution of state-of-the-art optical lithography systems is limited by diffraction, requiring the expensive shift to shorter wavelengths and higher numerical apertures to achieve better performance. Alternatively, near-field optical lithography systems are not limited by diffraction, but have received little attention outside of basic research due to their problematic requirement for intimate contact between a rigid mask and resist stack.

In contrast, absorbance-modulated lithography (AML), a relatively new lithographic technique, has achieved sub-diffraction limited resolution without requiring intimate contact [1]. This is achieved by placing a photochromic absorbance-modulation layer between the far-field optics and the resist stack. This layer can be switched optically from an opaque state to a transparent sate via exposure to λ_1, and switched back via exposure to λ_2. By combining an optical pattern of λ_2 consisting of optical nulls, such as a standing wave pattern formed via interference lithography, with uniform exposure of λ_1, one can optically activate an absorption grating in the photochromic layer. The underlaying photoresist is exposed through the transparent regions by λ_1. By controlling the ratio between λ_1 and λ_2 it is possible to control the size of these transparent regions allowing them to reach deep sub-wavelength dimensions. The problem of contact is circumvented since the photochromic layer can be spun on, intrinsically creating intimate contact between this optically activated mask and resist stack.

Similar to traditional near-field optical lithography the sub-diffraction limit resolution of AML is achieved by using the evanescent high spatial frequencies of the exposing wavelength to form the image in the photoresist. The evanescent nature of these spatial frequencies results in low image contrast and depth-of-focus, seen experimentally as limited process latitude. By choosing the correct polarization for λ_1 and integrating a plasmonic reflector into the resist stack it is possible to increase both contrast and depth-of-focus, improving the overall process latitude of AML.

In this work we provide experimental results demonstrating increased process latitude in AML. By using TM polarization for λ_1 increased process latitude is achieved compared to TE polarization. It is also found that the process latitude can be further improved by replacing the bottom anti-reflection coating with a planar silver layer, functioning as a plasmonic reflector for λ_1.

1. T.L. Andrew, H.Y. Tsai, and R. Menon, Science **324**, 5929 (2009).