

Lithographically Directed Surface Modification*
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As the semiconductor industry approaches the limits of Moore's Law, new approaches must be undertaken to continue to shrink feature sizes into the 10-45 nm range. Self-assembly of materials into lithographically useful features may be an effective route to achieving these feature sizes. Diblock copolymers consist of two chemically different polymer chains connected at one end by a covalent bond that can spontaneously form ordered structures at the molecular scale with domain dimensions of 10-45 nm, the size of these domains determined through control of the block molecular weights and the composition of the blocks. Diblock copolymers have been used by several research groups for self-assembly due to their ability to microphase separate to form ordered domains.

Diblock copolymers have been non-randomly ordered on surfaces by tuning the specific surface chemistry and surface energy to match that of the diblock copolymer through a series of film deposition, patterning, and etch steps, and thus direct the orientation and long-range order of the resulting diblock copolymer film. However, these current approaches rely on conventional lithographic patterning of the imaging layer involving multiple processing steps, and often the resolution of the self-assembled diblock copolymer is limited by the initial defining lithography.

We have developed a processing method that significantly reduces the number of steps necessary to yield a surface that directs material assembly. We employ a single resistless lithography step that directly changes the surface energy without requiring subsequent material deposition or plasma etch steps. Multiple surface modification agents have been investigated, and differences between chemical functionalities have been observed. These differences manifest in the surface energy vs. position aerial image, which are then translated to the ability for the patterned surface to direct diblock polymer self-assembly into low-defect periodic structures, which can exceed the resolution of current resists.

In this paper we will show how the surface energy changes in response to different exposure doses, and how this change can be related to the expected surface energy on the imaged wafer as a function of the aerial image intensity modulation. We will demonstrate how our newly developed lithographically directed self-assembly technique on a variety of modified surfaces can produce sub-45 nm half-pitch lines employing poly(styrene-b-methyl methacrylate) and interference lithography. The utility of different lithographic techniques (optical, EUV and electron beam) to modify the surface energy will also be demonstrated.

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