Approaches to Low Stochastics Resist Design for EUV Lithography

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Low stochastics, high sensitivity photoresists remain a goal for EUV lithography, particularly with the advent of high NA lithography. Here we present updated studies of two polymer systems with the goal of making improvements to resist systems using two different chemical approaches to minimize synthetic variability. In one system we work on scissionable poly(phthalaldehyde)s modified to enable incorporation of photoactive units on specific sites along the polymer chain. or at chain ends. In a second system we explore peptoid polymers that possess identical molecular size, composition and sequence with much higher molecular uniformity than possible by conventional synthetic techniques. Our goal is to build single component EUV resists of high molecular uniformity to tackle this stochastics issue and both show promise as materials capable of accomplishing that. Both systems as single component materials have been shown to possess a sensitivity of 10 - 20 mJ/cm^2 under EUV exposures and in some examples a resolution approaching 10 nm.

In our study of poly(phthalaldehyde) we have modified the basic building block by adding a substituent to enable incorporation of units that make the polymer both more susceptible to EUV exposure and more likely to depolymerize after exposure while remaining stable in the absence of radiation. Each chain is made of identical building blocks and by using ionic polymerization has a very narrow molecular weight compared to conventional CAR resists. Our premise is that while the polymer itself may not be of perfectly uniform molecular size (although with narrow dispersity as it is made by living polymerization methods), this is less important because the patterning mechanism involves depolymerization (conversion of polymer to monomer) and removal of the polymer in the exposed area. These materials have shown good stability and by attaching one depolymerization trigger to each backbone there is high chemical homogeneity. We can tune the volatility of the monomer and the unzipping conditions of the polymer to control performance in the EUV vacuum. Details of the performance of these resists will be discussed.

In our second low stochastics resist material, we explore the construction of polymers derived from peptoid units, an analog of peptides, but polymers that are achiral and in which substituents are located on the backbone nitrogen. This polymer family, prepared using an automated synthesizer originally developed for protein synthesis, results in each chain having an identical number of units in each chain, and identical composition and an identical sequence. Thus, each polymer is identical in contrast to conventional CAR resists and the effect of chain sequence has been shown to have dramatic effects on performance and development that cannot be observed with the imperfect polymers used today. Examples of the lithographic performance of these materials will be described with a focus on a specific high resolution, PAG-free single component peptoid EUV resist of high sensitivity.

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