Navigating Stochastic Challenges in EUV Lithography: Innovations in Materials and Metrology

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As extreme ultraviolet (EUV) lithography advances toward hyper-NA or beyond EUV, significant breakthroughs in patterning materials are essential for sustaining Moore's Law. Achieving atomic-scale control over spatial, temporal, and chemical properties is crucial to overcoming challenges related to stochastic effects and resist sensitivity. The ionizing nature of EUV radiation and its implications to drive image formation through radiolysis, brings emerging physics and chemistry challenges that demand a paradigm shift in the design of patterning materials for EUV lithography. As feature dimensions approach molecular scales, understanding and controlling sources of chemical stochastics (e.g., variations within resist composition, conformation or polydispersity) becomes increasingly important. In this talk, we will present recent efforts to design and test patterning material platforms that systematically interrogate properties conducive to minimizing chemical stochastics. For instance, we explore polypeptoids as EUV resists, enabling the construction of monodisperse, sequence-defined architectures with precise functionalization. Additionally, we discuss innovative approaches like molecular layer deposition, allowing controlled variability in resist networking density and composition.

Strategies to mitigate stochastic effects in EUV patterning may extend beyond traditional resists. We will also explore bottom-up materials with thermodynamic and self-assembling properties that may offer solutions for improving roughness and uniformity. This includes directed self-assembly and area-selective deposition techniques for pattern rectification and transfer.

Finally, understanding the origins of stochastic variations in radiolysis-driven patterning requires advancements in characterization techniques to probe the effects of EUV photoionization and the chemistry induced by cascades of secondary electrons. We will address the opportunities and challenges of multimodal characterization, focusing on secondary electron emissions and chemical imaging techniques to enhance our understanding of these complex processes.