Sub-10-nm Beam-Based Lithography and Applications

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Sub-10-nm lithography and, increasingly, sub-5-nm lithography are the new frontiers for nanopatterning. At these lengths scales, even macro-molecular self-assembly (for example based on block copolymers) faces challenges. And despite much understanding of the behavior of charged particles in resists at the sub-100-nm length scale that has been developed over the past 40 years, there have relatively few tests of the prevailing theories at the sub-10-nm scale. Instead, the quality of the nanoscopic theories have been based largely on inference from the quality of 100-nm-scale results.

We will present developments in the field of sub-10-nm electron-, and ion-beam patterning that have occurred in the past two years. We will discuss our recent results in developing higher-resolution exposure methods, including especially the potential impact of new development and exposing agents. Specifically, we will discuss exposures using electron beams with energy varying from 2 keV to 200 keV, and comparing these exposures and point-spread functions in the same resist systems. Metrology was performed in these cases by using both scanning and transmission electron microscopy.

We will present a method of electrochemical resist development by which the resist can be developed in deionized water. We will compare various development methods, with an aim to improving our understanding of the underlying mechanisms at play in limiting resist resolution.

Finally, we will present several applications that take advantage of robust beam-based lithography at the sub-10-nm length-scale either for further patterning (at an equal or smaller length scale) by using self-assembly, or for use in new nanoscale devices.