Time-dependent charging and degradation of photoresists under low-energy electron irradiation

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Understanding the interactions between low-energy electrons and photoresists is crucial for extreme ultraviolet (EUV) lithography, where 13.5 nm photons generate cascades of secondary electrons with energies below 20 eV. These low-energy electrons are the primary drivers of chemical transformations in photoresists. However, the impact of low-energy electrons on photoresist breakdown is poorly understood, and most studies overlook the charging effects occurred during exposure.

We investigate time-dependent charging and degradation of 25 nm thick PMMA films under 5–20 eV electron irradiation using low-energy electron microscopy and diffraction. By coupling secondary electron emission with a conductance-based charging model, we simulate dynamic surface potential evolution as a function of landing energy. Transient charging is shown to significantly alter the effective electron energy during exposure, complicating energy-dependent studies.

We develop a dynamic electron energy ramping scheme that compensates surface charging and maintains a constant landing energy. The approach enables controlled investigation of photoresist degradation at specific electron energies and provides new insight into stochastic charging-induced effects relevant to next-generation EUV and beyond-EUV photoresist design.

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