Integration of Electron-Beam Lithography and Atomic Layer Etching for Nanoscale Fabrication

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As semiconductor devices scale toward the atomic level, traditional plasma etching faces significant challenges regarding surface damage and lack of precision. In this work, we explore the integration of Atomic Layer Etching (ALE) with electron-beam lithography (EBL) to enable high-fidelity pattern transfer at sub-100 nm length scales. A systematic evaluation of multiple ALE process recipes is performed using a range of industry-standard electron-beam resists, encompassing both positive- and negative-tone materials, including poly(methyl methacrylate) (PMMA) and hydrogen silsesquioxane (HSQ). Etch characteristics such as profile control, surface roughness, etch rate, and selectivity are analyzed for each resist system.

Furthermore, the performance of resist masks (PMMA and HSQ) is benchmarked against SiO_2 hard masks for ALE patterning of silicon substrates. The results demonstrate the advantages and limitations of each masking approach and highlight the potential of combining ALE with EBL to achieve highly precise, low-damage etching for semiconductor fabrication.