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Model for atomic layer etching describes reaction mechanism for controlled silicon dioxide removal

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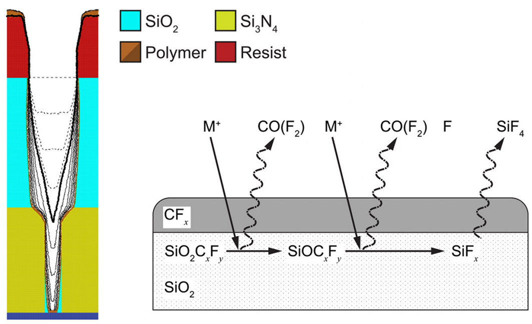
A first principles model of atomic layer etching describes the mass and energy transport through the polymer passivation layer required for selective etching, and eventual process optimization.



Plasma etching of diverse materials is a critical step in semiconductor manufacturing, enabling the creation of modern electronic devices by removing material to open conductor pathways or windows for further material growth. Most of today's etching methods are continuous, making it difficult to etch high aspect ratio structures or have precise control over material thickness.

Atomic layer etching is a promising new technique enabling these capabilities, though the need for further optimization is demanding a better understanding of its fundamental reaction mechanisms. A new 3-D computer model, developed by Huard et al., better describes the atomic layer etching process.

This method of etching can controllably and repeatedly remove one plane of atoms through the repetitive use of two self-limited plasma processes. When etching dielectric materials, the first step passivates the surface by depositing a polymer layer, and the second step uses the atomic species in the polymer to chemically remove only the surface atoms of the substrate at the polymer interface.

The model uses a first principles approach to describe the chemical reactions and reaction pathways during plasma etching, and includes the transport mechanisms through the polymer to the underlying etch interface of silicon dioxide or silicon nitride. The model reaction mechanism was developed through a combination of applying fundamental theory, experimentally measured reaction probabilities, and comparisons to previously published experimental data for feature profiles.

The unique ability of this model to consider transport through the polymer layer enables better understanding of the process to optimize, for example, selective etching. In this way, the process can be modified to increase throughput or better control the thickness of the etched materials to manufacture more complex devices on the same underlying substrate.

Source: "Transient behavior in quasi-atomic layer etching of silicon dioxide and silicon nitride in fluorocarbon plasmas," by Chad M. Huard, Saravanapriyan Sriraman, Alex Paterson, and Mark J. Kushner, *Journal of Vacuum Science and Technology A* (2018). The article can be accessed at https://doi.org/10.1116/1.5049225.