Yesterday, Today, and Tomorrow for High-Aspect-Ratio Contact Etching: Unraveling the Mysteries of Plasma-Surface Interactions with Modeling and Simulations

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The ever-growing demand for big data storage and processing has driven advancements in both the design and process technologies of advanced memory devices. In particular, the fabrication of high-aspect-ratio contacts (HARC) is a key process step. Etch throughput and profile control are crucial for reducing manufacturing cost and ensuring device performance. To meet these challenges, multiscale mechanistic understandings are essential for driving process and design optimization.

In this paper, we will discuss the fundamental etch mechanisms of plasma-surface interactions for HARC etching assisted by atomistic / plasma / profile modeling. We will review the underlying surface reaction mechanisms of the conventional fluorocarbon gas chemistry. We will also discuss the typical process challenges with etch rate and profile control, as well as various possible mitigation methods. Moreover, we will introduce how hydrogen admixture into the fluorocarbon chemistry can alter the behavior of dielectric etch rate and surface chemistry in a way that breaks conventional wisdom, especially at lower wafer temperatures. By unraveling and utilizing these underlying mechanisms derived from multi-scale simulations, we have been able to design new processes to achieve enhanced performance.