Plasma and Feature Scale Models for Etching of High Aspect Ratio Silicon Structures in Pulsed Inductively Coupled Plasmas

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Pulsed (power-modulated) plasmas have demonstrated several advantages compared to continuous wave plasmas and have become indispensable in etching of the next generation of microelectronic devices with characteristic dimensions below 10 nm. However, the large additional parameter space opened up through pulsing—e.g., which plasma source(s) to pulse, and pulse duty cycle, frequency, and phase—can complicate recipe development in the absence of a fundamental understanding of how plasma quantities may be impacted. Further, this complexity is added to an already challenging environment of multi-step processes, each of which may not be fully understood.

In this work, we consider a cycled, multi-step etch process and focus on the pulsing scheme used in the primary etch step. Through plasma simulation, we explore the impact of pulsing the inductive source and/or capacitive bias power on plasma quantities. We obtain temporally-resolved species densities, species fluxes, and ion energy and angular distributions at the wafer, with several pulsing schemes, duty cycles, and phases considered. Next, feature profile simulations of the etching of a high aspect ratio silicon structure are investigated, with the results of the plasma simulation used as inputs. We comment on how the pulsing scheme impacts etch rates, etch selectivity, and critical dimensions.