Feature Scale Modeling of Fluorocarbon Plasma Etching for Via Structures including Faceting Phenomena

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With the continuous miniaturization of electronic device structures which is necessary to improve performance, plasma etching challenges continue to evolve in the semiconductor industry [1]. Higher aspect ratios and higher density features are required for new device technologies and the precise modeling of etching processes can greatly aid manufacturing [1]. To that end, we have implemented a modeling methodology for feature scale fluorocarbon reactive-ion-etching (RIE) and integrated it into Silvaco’s Victory Process [2] simulator for evaluation purposes. The methodology (Fig. 1) integrates a bottom-up ray-tracing scheme [3] for the simulation of the fluxes associated with impinging plasma species. The fluxes feed a Langmuir set of surface coverage equations [4] (Figs. 2-4), which outputs either a substrate etching rate or a polymer deposition rate. The rates are provided to a level-set [5] topography engine which updates the geometry accordingly. We also implemented different angular yield functions for RIE and physical sputtering mechanisms (Fig. 5) to enable the reproduction of faceting phenomena [6]. We applied the developed methodology to a typical via etching of SiO₂ with an Ar/C₄F₈ plasma chemistry, adapting parameters from [4]. The simulated via (Fig. 6) was etched for 25s and exhibits a polymer sidewall; the shape and maximum thickness (17nm) agree with experimental data [4]. The faceting is observed at the mask material as expected (Fig. 6) and the tapering angle agrees with the experimentally observed angle of 45º [6]. The developed methodology can be extended to different materials and can be fully incorporated into TCAD workflows.

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observed at the mask material (Fig. 3). The difference in angular dependencies between mechanisms influences the shape of the via and gives rise to faceting observed at the mask material (Fig. 6) [6].