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Time-Multiplexed Deep Silicon Etching

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There is continuing interest in Time Multiplexed Deep Silicon Etch (TMDSE) processes to enable the fabrication of MEMS devices as well as through wafer vias. Yet, current knowledge of these processes is not comprehensive and has often emerged from designed experiments conducted to create/control feature profiles. The presented research helps to fill some of the gaps in our understanding. Experiments were conducted to understand the mechanisms that function during the deposition and etch steps of TMDSE. In our deposition step studies, we first etched trenches of various aspect ratios and subsequently deposited a thick passivation layer using the standard deposition step settings of the TMDSE process. The characteristics of the deposited layers were found to be very instructive. Contrary to typical assumptions, the experiments and analysis indicate that the contribution of ions is much more critical than the contributions of neutral molecules. This leads to large deposition rates in regions where it is NOT wanted and tiny deposition rates in regions where it IS wanted/needed! We relate this to the progression of feature undercut. In our etch studies, we began with standard trenches again and examined either the results of an extended etch step, or the results of both an extended deposition and etch steps. The experimental evidence suggests that the etchant species at higher aspect ratios become something besides the commonly assumed atomic fluorine. It may be that the primary etchant becomes molecular fluorine. (The etch profile characteristics appear consistent with molecular fluorine.) Our analysis was facilitated by a feature scale model.

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