Methodsto Enable Plasma Etching of Transition Metals with Atomic Scale Precision

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Advances in the semiconductor industry,historically based on Moore's Law and Dennard scaling, have become progressivelychallenging as device technology moves beyond the 7nm node. The ever-continuing trend to shrink devicesizes coupled with the advent of novel materials, multi-component materials oreven nanoscale materials, is growing the need for the ultimate etch solution:etching with atomic layer precision. Atomic layer etching is a promising path to answer the processingdemands of new devices at the angstrom scale. [1] Self-limiting reactions,discrete reaction & activation steps, or extremely low ion energy etchplasmas are some of the pathways being pursued for precise sub-nanometermaterial removal. In this presentation,the ability to achieve atomic layer etch precision is reviewed in detail for thepatterning of metal nitrides such as TiN and TaN. These materials are often utilized innon-volatile memory applications as hardmasks for the patterning of the activememory layers and ultra-high selectivity to the organic mask is critical tomaintaining dimensional control. In thispresentation, we will review work employing a plasma-enhanced atomic layer etch(PE-ALE) process with sequential cycles of Cl2 (deposition) and He/H2 (etch) chemistries,separated by purge steps, to pattern TiN and TaN lines using an organicplanarizing layer (OPL) mask. Comparedto a continuous wave Cl2 plasma, the PE-ALE process demonstrated virtually nometal residue on the OPL mask and SiOx stop layer; as well as a powerful knobfor tuning the profile and CD of the features by controlling the purge timesbetween cycles. [2]

[1] K. J. Kanarik, T. Lill, E. Hudson, S. Tan, S.Sriraman, J. Marks, V. Vahedi,
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