Title : Variable morphology highly-conformal diffusion barriers for advanced memory and logic applications

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Abstract : Atomic layer deposition (ALD) of metallic ternary TiSiN films is associated with a variety of morphological and structural variations. Among these phenomena are the thickness and stoichiometric-dependent amorphous to crystalline phase transitions, film density changes, surface roughness and film resistivity variations. In the case of TiSiN films deposited via thermal ALD at temperatures of about T<600°C, using chlorine-based Si precursors, titanium tetrachloride and ammonia, the film structure is highly dependent on the total Si incorporated in the film. In this work, we demonstrate the tunability of crystalline phase in highly conformal TiSiN films with varied Si content. TiSiN films were deposited on high aspect ratio structures using a Eugenus 300mm commercial QXP mini-batch system. Film thickness and Si content were varied, and corresponding structural analysis was performed using multiple characterization techniques. X-ray diffraction and reflectivity studies of these films showed a reduction in film density and transition from nano-crystalline to pure amorphous phase with increase in Si fraction. Cross-section high resolution transmission electron microscopy (HRTEM) and selected area electron diffraction (SAED) pattern analyses corroborates with the X-ray analysis that high-Si TiSiN films exhibit a fully amorphous structure. Moreover, control of Si fraction in the film enables tuning of the morphology from polycrystalline to fully amorphous; in all cases, excellent step coverage on high aspect ratio structures were obtained.

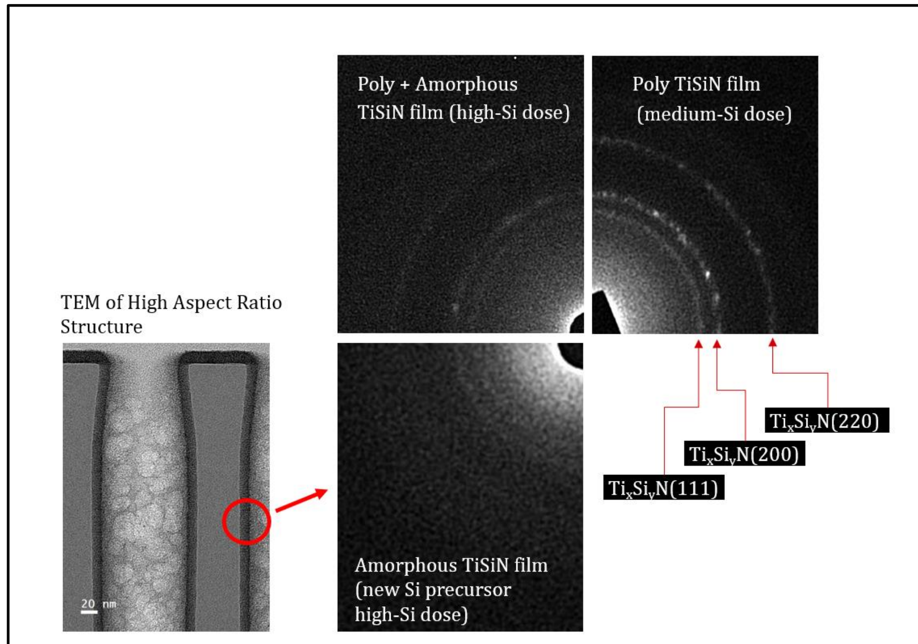

Figure 1. Cross-sectional TEM and various selected area diffraction patterns of highly-conformal polycrystalline to amorphous TiSiN films.