Enabling smooth and conformal film growth via separate surface treatment during atomic layer deposition of cobalt

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As devices continue to scale down to N7 technology node and beyond, there have been extensive efforts to replace the current tungsten metal with alternative metals due to reduction in current-carrying cross-section, increase in electron scattering, and fill challenge of current tungsten or copper process in narrow trenches. Cobalt is considered a promising candidate because of its low electron mean free path and high melting point associated with resistance to diffusion (i.e., electromigration), especially, in source/drain metal electrodes and local/back-end interconnects in logic devices. The CCTBA cobalt precursor is useful due to its ability to produce pure cobalt films; however, it has an intrinsic instability issue, causing dimerization or polymerization with time. In this study, two new cobalt precursors have been investigated to achieve pure cobalt film with good step coverage and smooth morphology. Cobalt film growth behavior and film properties are affected by precursor design with different precursor stability and volatility. Precursor A is less volatile and more stable, producing slow film growth and smooth film morphology but relatively high carbon impurities. In comparison, precursor B is more volatile and less stable, producing fast film growth with rough film morphology by CVD process. However, ALD process enabled improved controllability in film nucleation, step coverage, and morphology by separate surface treatment and low process temperature. Pure and crystalline ALD Co films were obtained with film resistivity at approximately 12 µohm-cm at 25 nm, which is comparable to that of CCTBA. Cobalt gapfill behavior within small features using ALD cobalt process has also been studied. Detailed results including film characterization and gapfill performance will be presented.