Impact of Plasma Process on Source/Drain Epitaxy Film

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Middle-of-Line (MOL) contact open by plasma etching is a very critical step in logic IC fabrication. Source/Drain Epitaxy (S/D Epi) film as a key element in device transistors controls device performance in various aspects. S/D Epi film damage induced by plasma etch processes have been one of the challenges in MOL integration. Epi film damage includes surface roughening and oxidation, crystal structure relaxation and elemental doping, all of which could lead to uncontrolled variation and degradation in electrical performance of the devices. In this paper, SiGe (known pMOS S/D material) film damage post varying CCP plasma conditions have been studied by utilizing different characterization techniques including X-ray photoelectron spectroscopy (XPS), Transmission Electron Microscope (TEM) / Energy-dispersive X-ray spectroscopy (EDS), Rutherford backscattering spectrometry (RBS) and Secondary ion mass spectroscopy (SIMS). Various CCP plasma conditions include changes in gas chemistries (N/H/O/C/F/Ar), plasma source/bias power and chamber configurations. Electrical response on short loop device wafers have been collected and correlated with observed physical/chemical changes in S/D Epi film post plasma processes. We also performed molecular dynamics, quantum chemistry and chamber scale simulation to understand the fundamental chemical behavior and characterize the surface/chemical properties between provided plasma and SiGe film at various ion energy and ion/radical flux in an atomic/molecular level. The study provides a comprehensive understanding in plasma damage to S/D Epi film and a fundamental guideline in optimizing plasma processes to achieve ideal contact open etch with minimal damage on source/drain Epi film.