A High Depth Resolution MEIS Analysis Of Ultra Thin STO/TiN Layers On Si For DRAM MIM Capacitors

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ABSTRACT

The physical characterisation of atomic layer deposited (ALD) Sr$_x$Ti$_{1-x}$O$_y$ (STO) dielectric material films, a few nm thick, for application in metal-insulator-metal capacitors (MIMcap) in the form of high aspect rather than planar geometries in Dynamic Random Access Memory (DRAM) devices [1], represents a considerable metrology challenge. The analysis is important since there is currently a renewed interest in the behaviour of such layers, especially when combined with TiN electrodes, which is a low cost alternative to Pt or Ru metal ones [2]. Medium energy ion scattering (MEIS) in conjunction with energy spectrum simulation has been demonstrated to possess the capability of yielding quantitative information on the structure and composition of shallow planar layers with sub-nm depth resolution at the surface in a comparison with other techniques in an analysis of HfO$_2$ and Hf$_x$Si$_y$O$_2$ gate dielectric nanofilms [3]. Important factors that affect the quantification of MEIS information such as neutralization, Andersen correction and the changing energy bin width across the energy spectrum will be briefly discussed.

Sample structures investigated were a full MIMcap structure comprising of a 2 nm TiN top electrode, a 3 nm STO (Sr-rich or stoichiometric) insulator layer and a 3 nm TiN bottom electrode, both before and after annealing at 650°C in N$_2$ and these were preceded by subsets of this structure. MEIS conditions used were 100 keV He ions in the double alignment configuration, [-1-11] in, [111] or [221] out, yielding scattering angles of 70.5 or 90°.

Further to the determination of the composition and thickness of the layers investigated, MEIS studies have enabled the monitoring of interface behaviour, providing information on processing and interface issues such as the effect of the TiN sputter deposition process, the near-surface Sr enrichment of an uncapped Sr rich STO layer, Ti interdiffusion into the Sr rich STO upon annealing and the apparent higher thermal stability of the stoichiometric STO/TiN system against Ti diffusion.

FIGURE 1. MEIS spectra and profiles of a TiN/STO/TiN MIMcap structure before and after annealing to 650°C in N$_2$.

REFERENCES