Composition and structure of high-k materials on silicon

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The spectacular success of silicon technology relies to a large extent on the excellent properties of SiO_2 and the SiO_2/Si(100) interface. Very soon, however, the thickness of SiO_2 layers in state-of-the-art microelectronic devices will become so small that quantum mechanical tunnelling of electrons through this insulating layer will give unacceptable electric leakage currents. Work is therefore proceeding at a feverish pace in many laboratories, both in academia and in industry, on finding replacement materials for SiO_2 with higher dielectric constant (high-k).

We will present results on the structure and composition of two different classes of potentially interesting high-k materials. Our main experimental tool is medium energy ion scattering (MEIS). MEIS can be thought of as a high-resolution, low energy version of conventional Rutherford Backscattering (RBS). By using lower ion energy (100 keV in our case) and a high resolution electrostatic ion energy analyzer, MEIS can achieve a depth resolution of ~ 3 Å in the near surface region.

We will first discuss amorphous or polycrystalline films of materials such as HfO_2 and ZrO_2. We will present data on their thermal stability on silicon and the composition and structure of their interface with silicon.

A second class of systems consist of epitaxial crystalline thin films on Si. We have examined one such system, $SrTiO_3$/Si. We have distinguished between epitaxial/amorphous regions, characterized the chemical composition of the $SrTiO_3$/Si interface and obtained atomic scale data on the film structure. Possible models of the transition region and mechanisms of Ti, Si, Sr and O diffusion and incorporation in the interface region will be discussed.

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