Morphology of HfO_2 Dielectric Films

Beamline: X23A2

Category of Researcher: PRT member

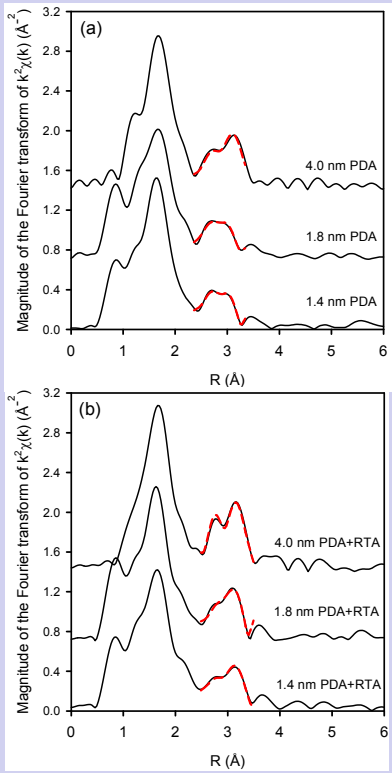
Technique: EXAFS

Researchers & affiliations: P.S. Lysaght (SEMATECH), J.C. Woicik (NIST), M.A. Sahiner (Seton Hall), B.-H. Lee and R. Jammy (SEMATECH)

Publication:
Characterizing crystalline polymorph transitions in HfO_2 by extended x-ray absorption fine-structure spectroscopy, *Appl. Phys. Lett.* 91, 122910 (2007).

Motivation: High-resolution spectroscopic techniques capable of characterizing subtle film and interface stoichiometric variations as a function of gate-stack layer deposition and subsequent anneal processing have emerged as critical requirements for the identification of microsctructure driven mechanisms that limit or enhance the electrical perfromance of Hf-based complementary metal oxide semiconductor devices.

Results: EXAFS of atomic layer deposited HfO_2 films on Si(001) indicate: 1) Increase in atomic order with increasing film thickness for each anneal temperature and with increasing anneal temperature for each film thickness. 2) Orthorhombic to tetragonal to monoclinic transformations. 3) Greater retention of the higher permittivity metastable tetragonal phase consistent with surface energy driven critical grain size phenomenon.



The Fourier transformed EXAFS data for 1.4, 1.8, and 4.0 nm thick HfO_2 on Si(001) (a) following the PDA process of 700 °C for 60 s in NH_3 ambient and (b) following the PDA (700 °C for 60 s in NH_3) + RTA (1000 °C for 10 s in N_2 ambient) process.