



Contribution ID: 352

Type: Poster

Structural properties and room temperature ferromagnetism in nanocrystalline HfO₂

Tuesday, 18 September 2018 17:15 (15 minutes)

Hafnium oxide (HfO₂) crystallizes in the monoclinic phase at room temperature which undergoes a phase transformation to tetragonal and cubic at 1700 °C and 2600 °C, respectively. Herein, we present a detailed structural and magnetic properties of nanocrystalline HfO₂ powders synthesized by a Pechini type sol-gel method followed by calcination at 900 °C in air. X-ray diffraction and Le-Bail profile refinement revealed that HfO₂ crystallized in monoclinic phase, space group, P2₁/c with an average particle size of ~40 nm. The lattice spacing calculated from high resolution transmission electron microscopy (TEM) micrograph and selected area electron diffraction (SAED) pattern further endorse the formation of monoclinic phase in HfO₂. Magnetic measurements have shown that HfO₂ exhibits a noticeable hysteresis loop manifesting ferromagnetism at room temperature in contrast to the diamagnetic behaviour in bulk. Room temperature ferromagnetism observed in nanocrystalline HfO₂ has been the subject of great interest for spintronic device application. However, the origin of intrinsic ferromagnetic ordering in diamagnetic systems like HfO₂ is still not clear and sought further systematic studies. In order to have a better insight, polarized neutron reflectometry (PNR) technique can be utilized efficiently for probing the magnetic properties of HfO₂ thin films. PNR provides feasibility of excluding direct magnetic contributions of substrates resulting in absolute magnetic behaviour analysis with high accuracy.

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Session Classification: Poster session 2

Track Classification: P6 Nanomaterials and nanostructures