BIO Web of Conferences **129**, 22031 (2024) https://doi.org/10.1051/bioconf/202412922031
EMC 2024

Structural phase transition induced microstructure changes in V2O3 based hybrid magnetic heterostructures

Prof. Unnar Arnalds[1]
[1]University of Iceland, Reykjavik, Iceland

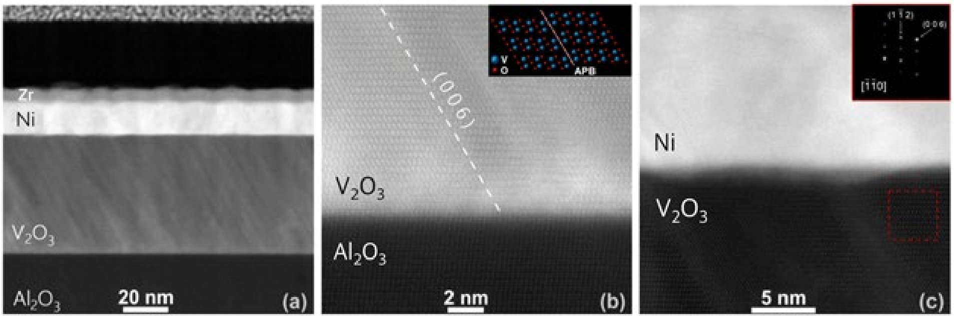
Vanadiumsesquioxide (V_2O_3) stands out in the realm of transition metal oxides for its distinctive and multifaceted phase transitions, offering a rich ground for exploration in the context of structural, electrical and magnetic properties [1, 2]. At room temperature, V_2O_3 is in a rhombohedral phase, exhibiting metallic properties and upon cooling to below ~150 K it undergoes a structural phase transition to an insulating monoclinic phase. Through the transition the material also changes from a paramagnetic state to a low temperature antiferromagnetic state and has been observed to induce an exchange bias into overlying magnetic layers [3].

In this work we present an investigation on the interplay between the microstructure of V_2O_3 thin films, deposited using reactive dc magnetron sputtering, and their structural properties during the phase transition. Specifically, we examine the changes in the microstructure during the phase coexistence region of the V_2O_3 layer and how these changes correlate with alterations in the magnetic properties of overlying magnetic layers in V_2O_3/Ni heterostructures [4].

Using scanning transmission electron microscopy (STEM) using high-angle annular dark-field (HAADF-STEM) imaging, energy dispersive x-ray analysis (STEM-EDX) and electron energy loss spectroscopy (EELS) we investigate the stoichiometric composition of the films and confirm their crystalline quality at the sub-nm lateral scale and observe an atomically flat interface between the Al_2O_3 substrate and the V_2O_3 layer, as well as a sharp interface between V_2O_3 and the overlying magnetic Ni layer.

The simultaneous presence of two phases in V_2O_3 during its structural phase transition was identified with temperature dependent high resolution x-ray diffraction measurements performed at the BM28 (XMaS) beamline at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. The measurements reveal an increase in surface roughness during the transition which is attributed to the coexistence of the two phases in different regions of the film. During the phase coexistence region we observe a concomitant increase in the coercivity of the magnetic layer correlated with the increased roughness of the V_2O_3 surface.

Graphic:



Keywords:

Phase transitions, STEM, Magnetism, Heterostructures

Reference:

[1] Controlling metal–insulator transitions in reactively sputtered vanadium sesquioxide thin films through structure and stoichiometry. E.B. Thorsteinsson, S. Shayestehaminzadeh, A.S. Ingason, F. Magnus, and U.B. Arnalds. Scientific Reports 11, 6273 (2021).
[2] Tuning metal-insulator transitions in epitaxial V_2O_3 thin films. E.B. Thorsteinsson, S. Shayestehaminzadeh, and U.B. Arnalds. Applied Physics Letters, 112, 161902 (2018).
[3] Reversible exchange bias in epitaxial V_2O_3/Ni hybrid magnetic heterostructures. K. Ignatova, E.B. Thorsteinsson, B.A. Jósteinsson, N. Strandqvist, C. Vantaraki, V. Kapaklis, A. Devishvili, G.K. Pálsson, an U.B. Arnalds. Journal of Physics: Condensed Matter 34, 495001 (2022).
[4] Phase coexistence induced surface roughness in V_2O_3/Ni magnetic heterostructures. K. Ignatova, E. Vlasov, S. D. Seddon, N. Gauquelin, S. Bals, T. P. A. Hase, and U. B. Arnalds. APL Materials 12 (2024). doi: 10.1063/5.0195961