

Sub-3nm cobalt nanoparticles embedded in titania glass via ion implantation studied by polarised neutron reflectometry

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Synthesis of stable metallic cobalt particles at the nanoscale is challenging using chemical methods due to their unstable nature and their tendency to oxidise. Nevertheless, ultra-small metallic cobalt nanoparticles offer unusual electronic and magnetic properties including large spin moments and magnetic anisotropy[1] [2]. Here we report the use of ion beam implantation to synthesis stable metallic cobalt nanoparticles embedded within TiO₂-x thin films. Scanning transmission electron microscopy (STEM) images revealed that the Co nanoclusters were around 1-3 nm in size. The blocking temperature of Co nanoparticles is estimated to be $T_B = 6.5$ K from the field-cooled and zero-field-cooled magnetization curves. Polarised neutron reflectometry (PNR) measurements reveal superparamagnetic behaviour with a strong temperature dependency due to the small size of the nanoclusters. The nuclear scattering length density, together with near-edge X-ray absorption spectroscopy (NEXAFS) show that the magnetic cobalt clusters are metallic and unoxidized below the TiO₂-x surface, whereas near the surface the clusters are prone to form cobalt oxides in a magnetic dead layer that extends over a few nanometers. Our results show that ion beam synthesis can produce ultra-small particles that are not possible with other methods, and these particles survive for long periods without much oxidation.

References:

1. Controlling Cobalt Nanoparticles. Science, 2001. 291(5511): p. 2043-2043.
2. Cortie, D.L., et al., Enhanced Magnetization of Cobalt Defect Clusters Embedded in TiO₂—Films. ACS applied materials & interfaces, 2017. 9(10): p. 8783-8795.

Level of Expertise

Student

Speakers Gender

Male

Do you wish to take part in the poster slam

Yes

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