Experimental report

14/01/2016

Proposal: 5-54-200 **Council:** 4/2015

Title: Depth Profile Investigation of LaAlO3(001)/EuO(001) using Polarised Neutron Reflectivity

Research area: Physics

This proposal is a new proposal

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Samples: LaAlO3(001), EuO (001) and Au

Instrument	Requested days	Allocated days	From	To
D17	4	4	19/11/2015	23/11/2015

Abstract:

The aims of the proposed experiment are to study the magnetic and structural depth profile of the LaAlO3/EuO system and to investigate the structural and magnetic imperfections of the interface by specular reflectivity of a monochromatic polarised beam at D17. Polarised neutron reflectivity (PNR) has the advantage of probing multilayer systems while distinguishing the properties of each layer. Therefore, detecting an enhancement in the magnetisation at the interface, which may arise as a result of the formation of a two-dimensional electron gas (2DEG) can be achieved. The results obtained from this experiment will give a better understanding of the mechanism with which a 2DEG can be formed in LaAlO3(001)/EuO(001) in particular and for oxide interfaces in general. As large proportion (~47.86%) of the naturally occurring Eu contains the isotope, 151Eu, which has an energy-dependent coherent scattering length [1]. Therefore we plan to use monochromatic PNR to determine accurately the magnetic moment of the EuO layer and the interface.

Depth Profile Investigation of LaAlO3(001)/EuO(001) using Polarised Neutron Reflectivity

Directly involved in the measurements: Razan Aboljadayel, Nina-Juliane Steinke, Max Hawkins, Adrian Ionescu and Thomas Saerbeck

Co-Proposers: Kurt R.A. Ziebeck, Crispin H.W. Barnes and Sean Langridge

Introduction

The aims of the proposed experiment were to study the magnetic and structural depth profile of the LaAlO3/EuO system and to investigate the structural and magnetic imperfections of the interface by specular reflectivity of a monochromatic polarised beam at D17. Polarised neutron reflectivity (PNR) has the advantage of probing multilayer systems while distinguishing the properties of each layer. Therefore, detecting an enhancement in the magnetisation at the interface, which may arise as a result of the formation of a two-dimensional electron gas (2DEG) can be achieved. The results obtained from this experiment should provide a better understanding of the mechanism with which a 2DEG can be formed in LaAlO3(001)/EuO(001) in particular and for oxide interfaces in general. As large proportion (~47.86%) of the naturally occurring Eu contains the isotope, 151Eu, which has an energy-dependent coherent scattering length. Therefore we plan to use monochromatic PNR to determine accurately the magnetic moment of the EuO layer and the interface.

Experiment

The effect of substrate termination on the formation of 2DEG was investigated for the LaAlO3(001)/EuO(001) system by using PNR with an applied field of 0.1 T at 195 K (above the Tc=69 K of euO) and at 5 K (well below Tc), and of 350 Oe around the Tc at 64 K, 69 K and 72 K, where the first measurement is used as a structural refinement. Two 1.8 cm x 2 cm substrates of LaAlO3(001) were used for this purpose. One of the substrates was etched in NaOH and thermally annealed in air at ~1000 °C for 10 hours to create a LaO termination (Fig.1 a). The other substrate was etched with HCl in ultrasonic bath for 5 minutes to establish a AlO2 termination (Fig.1 b). As the latter termination cannot lead to a “polar catastrophe” it is not expected to create a 2DEG when it is interfaced with EuO, and thus it can be used as a reference sample. After that both substrates were transferred into a magnetron sputtering system to grow 50 nm of EuO at RT by co-sputtering of Eu and Eu2O3 and then capped with 15 nm of Au.

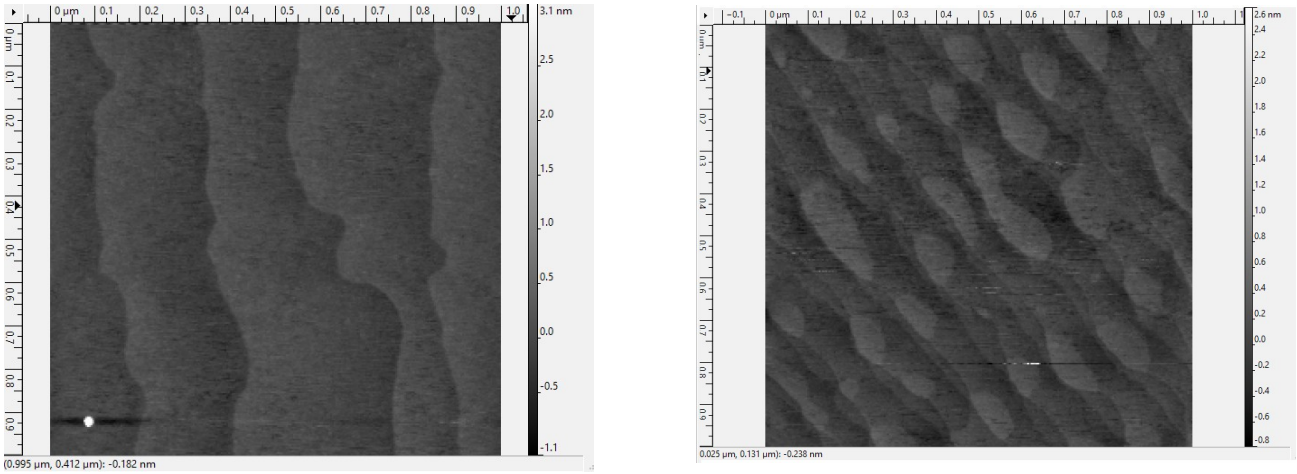

Figure 1: (left) a) AFM images of a LaO terminated substrate and of (right) b) AlO2 terminated LaAlO3(001) surface before deposition of the EuO.

Previous to the PNR measurements the two samples were thoroughly analysed by XRD (Fig.2 a), XRR and SQUID (Fig. 2 b) magnetometry as well as low energy muon SR.

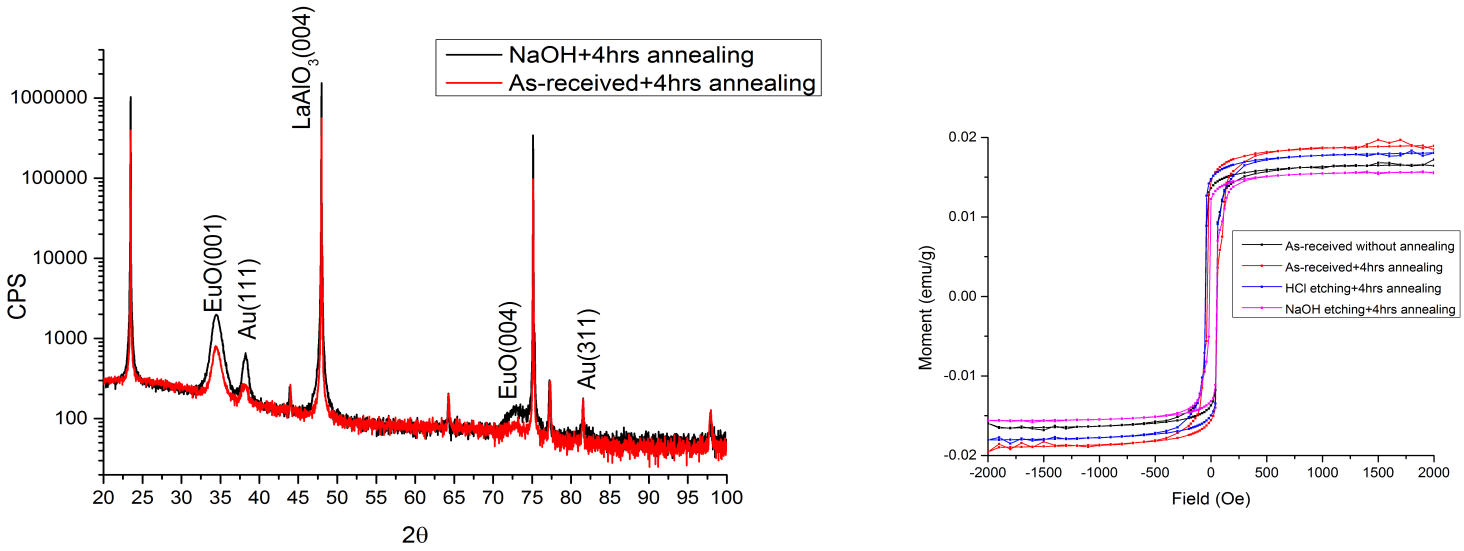

Figure 2: (left) a) XRD scan of two EuO(001)/LaAlO3(001) samples showing the right phase and indicating an epitaxial relation. (right) b) Magnetisation versus field of the different samples with different surface terminations.