Magnetism Reflectometer

H. Ambaye, R. Goyette, A. Parizzi, F. Klose and G. Felcher

The SNS Magnetism Reflectometer is one of the first three instruments that became operational in 2006 soon after its construction was completed in May 2006. The first data sets were collected in July 2006 shortly after the completion of the instrument readiness safety review. The Magnetism Reflectometer shares a common primary beam port and shutter with the SNS Liquids Reflectometer (BL4B) from which it is separated by 4.8° in horizontal angle. Individual secondary shutters allow operating the two instruments independently. The instrument is shown in Fig. 1 below.

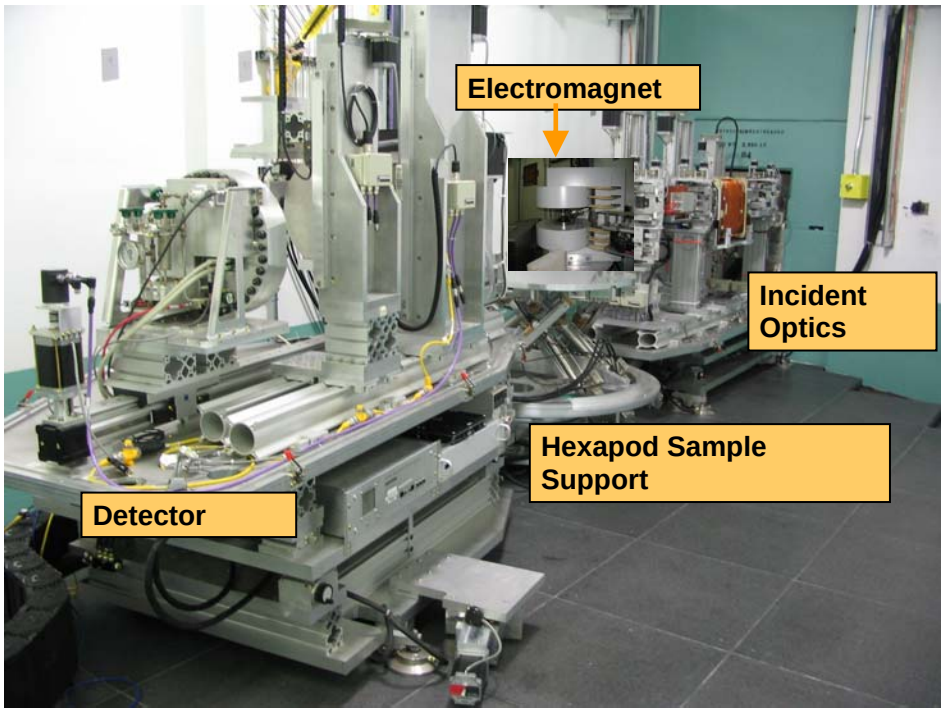

Fig.1

In the last several years since the start of the field called diluted magnetic semiconductors (DMS), several other systems have been discovered that show ferromagnetism without the inclusion of transitional metal (TM) and rare-earth (RE) metal atoms[1]. The DMS studies magnetic impurities in nonmagnetic traditional semiconductors. One of those new systems is the observation of ferromagnetism in doped oxide thin films without the presence of TM or RE atoms[1]. In spite of accelerated interest in these systems, the exact mechanism responsible for the occurrence of the magnetic properties in those materials is not well understood or established.

In this report we will present the investigation of magnetic MgO thin fillm, MgO:N(2.2%) at the SNS magnetism reflectometer. It is 2.2% nitrogen doped MgO thin film.The sample is approximately 500A thick and is provided by Staurt Parkin's group at IBM, Almaden[2]. The doping process creates holes on oxygen there by creating local magnetic moments. A very simplified explanation on how the magnetic moment could have developed in the system. The magnetic signature in the system is observed after the system is annealed at 750C as shown in Fig.2a. No evidence of ferromagnetism is observed in the as-deposited MgO:N film. The pure MgO film also shows no magnetic signature either in the as-deposited film and annealed film which is an indication that the magnetic moments observed in the Nitrogen doped MgO film comes from the introduction of Nitrogen.

---

[1] I.S Elfimov, A Rusydi, S. I. Csiszar, Z. Hu, H.H. Hsieh, H. –J. Lin, C. T. Chen, R. Liang, and G. A. Sawatzky, PRL 98, 137202 (2007).

[2] Stuart S.P. Parkin, F.R.S., IBM Fellow; Director, IBM-Stanford Spintronic Science & Applications Center (SpinAps), IBM Almaden Research Center, 650 Harry Road, YHSA-D1, San Jose, CA 95120-6099, USA

The system as you can see in Fig.2b shows a maximum magnetic moment of 8emu/cc at 2.2% nitrogen concentration. This is a very weak magnetic signal; approximately 1/200 of the magnetic moment of a-Fe. A small fluctuation in the state of the polarized neutrons during the flipping process could significantly affect the detection of the presence magnetic signals in the system. Therefore, maintaining the same condition when flipping between up and down spin states is required. However, this was not the case when the experiment was performed.

The objective of this polarized neutron scattering experiment is, therefore, to study the depth resolved magnetic structure of the system to see if it shows a uniform magnetization and where this net magnetic moment arises from-surface effect or bulk. The neutron data both for the polarized beam and unpolarized beam are shown in Fig.3a and 3b, respectively. The spin asymmetry analysis shows around 5% polarization indicating the existence of magnetic moment in the system. This study is not yet completed. Further study of the system will continue in the November, 2008 run cycle.

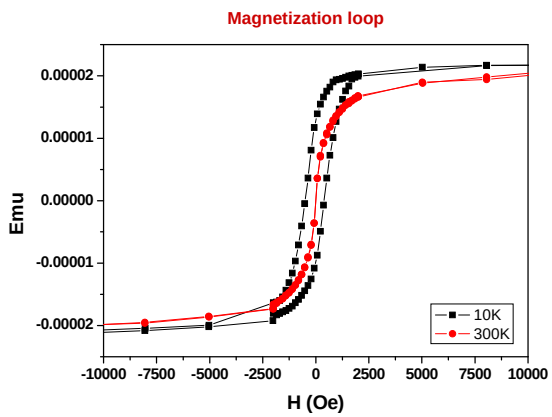

Fig.2a

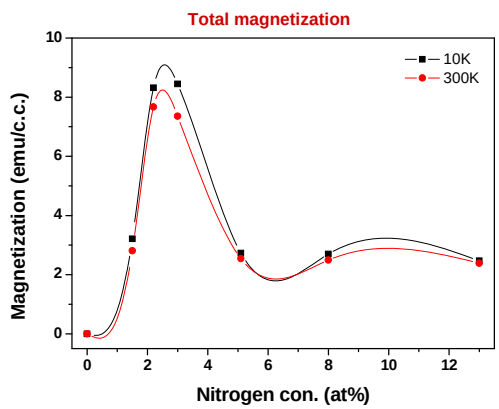

Fig.2b

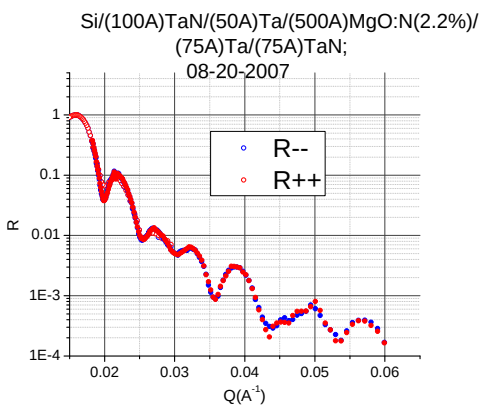

Fig.3a

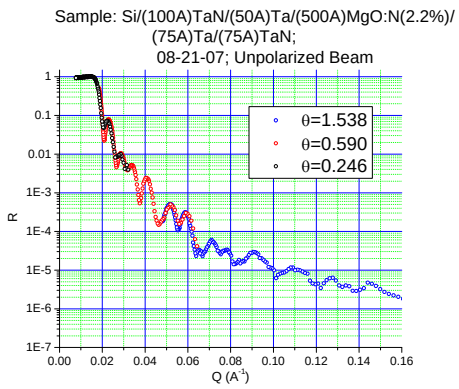

Fig.3b