RXS Study of the Verwey Transition in Epitaxial Magnetite Film

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Introduction

Research interest of bulk magnetite had been focused on the origin of Verwey transition for a long time. At BL15B2 and BL17B1 of NSRRC, our group utilized high-resolution synchrotron x-ray to study the epitaxial Fe_3O_4 layer of thickness ~800Å on MgO(001). We found no evidence of structural transformation in our coherently strained film down to 100°K, as referred to T_v=122°K in the case of bulk magnetite crystals. Our resonant x-ray scattering (RXS) work of magnetite film done at NSRRC in the past was limited to some static phenomena such as determination of lattice constants, thickness, lattice match between sample and substrate. we decide to deepen our understanding on the sample system of interest. .

Whether charge order below T_v or not in the bulk magnetite crystal is now still on debating. Although research works have been intensively published in the literature (especially since 2000), the puzzle still sits on its messy complexity. Relative little information of the details of Verwey transition in magnetite thin films has been addressed. Our proposed RXS study on the possible effect of orbital ordering at Verwey transition in magnetite films could serve a pioneering work from the aspect of applying external tensile strain on the subject of interest. This approach is essential to couple with the internal strain which drives the structural transformation at the transition temperature

Experimental Method

We use a new sample of 1200A which is thicker than the critical thickness. R-T curve has been measured before hand. Then we utilize the bright BL17B1 to perform RXS technique.

Result

We do confirm our previous finding about DANES spectra of (115) in Magnetite. Some new data were also obtained but haven't analyzed yet. More beamtime is needed to make breakthrough to new discoveries.

Conclusion

The nature of Verway transition of epitaxial magnetite film is worthwhile to investigate further . We'll continue our effort in the near future.

References

[1] D.J. Huang, p.U6 Eleventh Users' Meeting Booklet, NSRRC , ROC, (2005).

[2] J. García, *et al.*, PRL **85**, 578 (2000); PRB **63**, 054110 (2001).

[3] J.P. Wright, J.P. Attfield, and P.J. Radaelli, PRL **87**, 266401 (2001).

[4] B.Tan, H.H.Hung,and G. Chern,"Synchrotron X-ray Analysis of the MBE-Grown Fe_3O_4 Epilayer on MgO(001)",published by Journal of Chinese Physics in June ,2005.

Expected Outcome

By using the good sample in quality and fine low-temperature device, we hope that we could obtain reliable data which have not been obtained by others before. After suitably arranging these data we could gain knowledge about the feature of Verwey transition under the interfacial influence of tensile strain. We may publish our findings to PRB within a year or two.

(A) Why Synchrotron Radiation is Needed

RXS measurements definitely need synchrotron radiation x-rays. Because of thin thickness (about 90nm) and then low scattering volume in our thin-film sample system, we are indeed in demand of beamtime allocated at brilliant beamlines of NSRRC. To share people sense with our previous experiences, the RXS signal (from forbidden reflections) of a high-quality 90nm-thick magnetite epilayer is about 1cps at bending BL15B2 and 50cps at wiggler BL17B1.

(B) An estimate of the number of shifts required and the reason for using the beamline [Note that a proposal is active only for six consecutive cycles (i.e. two years) after its acceptance.]

1. BL17B1

(1) Total 45 shifts of beamtime are required and 15 shifts in 2006-1.

(2) As limited by the handy cryostat as well as fitting diffractometer we could utilize at our domestic beamlines, only preliminary studies (but extremely important to further meaningful exploration) are panning at BL17B1 at NSRRC.

2. SP12B1

(1) Total 45 shifts of beamtime are required and 15 shifts in 2006-1.

(2) Based on what we would learn from studies at BL17B1, we should get prosperous end results from the much better arrangement of instruments available at SP12B1 (i.e., BL12B2 of SPring-8).

(C) A list of Ppublications relevant to NSRRC Beamlines

1. Publications

a. 譚言正, 洪雪行, 陳 恭, 民 92 年四月(2003), 磁鐵礦磊晶薄膜的高解析度 X 光結構分析,嘉義大學學報 74:67-76

b. B. Tan, H.-H. Hung and G. Chern, "Synchrotron X-ray Analysis of the MBE-Grown Fe3O4 Epilayer on MgO(001)", Chinese Journal of Physics **43**, 481 (2005).

2. Abstract Title for NSRRC Users' Meeting

a. H.-H. Hung, B. Tan and Q. Liang, Oct. 28-29 (2003), Nineth Users' Meeting,
"Resonant X-ray Scattering from Fe3O4 Epilayer MBE-Grown on MgO(001) :
Ordering of of the Localized Empty States"

b. J. W. Chen, B. Tan and G. Chern, Oct. (2001), Seventh Users' Meeting,
"High-Resolution XRD Characterization of Epitaxial Fe3O4 Films on MgO(001)"

3. Abstract Title for NSRRC Activity Reports

In preparation.