Atomic structure and magnetic circular dichroism of antiphase boundary defects in $NiFe_2O_4$ thin films

Z.C.Wang[1], X.Y.Zhong[1], L.Jin[2], H.Yanagihara[3], E.Kita[3], H.B.Jiang[1], R.E.Dunin-Borkowski[2]

[1]National Center for Electron Microscopy in Beijing, School of Materials Science and Engineering, Key Laboratory of Advanced Materials (MOE), The State Key Laboratory of New Ceramics and Fine Processing, Tsinghua University, Beijing 100084, China,[2]Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C) and Peter Grünberg Institute (PGI), Forschungszentrum Jülich, D-52425 Jülich, Germany,[3]Institute of Applied Physics, University of Tsukuba, Tsukuba 305-8573, Japan

Email:wangzc15@mails.tsinghua.edu.cn

The presence of antiphase boundary (APB) defects is responsible for reduced spin polarization and magnetism in spinel ferrites[1,2]. There is also considerable discussion about the relationship between the atomic structures of APBs and their magnetic properties[3]. Electron magnetic circular dichroism (EMCD) was demonstrated experimentally in 2006 for a specific diffraction geometry[4]. Since then, the spatial resolution of EMCD has been improved to approximately 1 nm using nanobeam diffraction[5]. In 2013, we developed a site-specific EMCD method for magnetic structure determination and achieved EMCD spectra with high signal-to-noise ratio[6]. Here, we combine site-specific EMCD in nanobeam diffraction mode with high-resolution HAADF imaging, in order to simultaneously determine the magnetic circular dichroism and atomic structure of APBs in $NiFe_2O_4$ thin films.

We find the atomic structures of APBs that are formed on {111} planes by a crystallographic translation of 1/4a $[0\bar{1}1]$ using HAADF imaging. The EMCD signals at such defects were obtained using an electron beam with a diameter of ~1 nm and compared with signals obtained from a perfect single crystalline region under the same illumination and acquisition conditions. We demonstrate experimentally that the strength of the magnetic circular dichroism at APBs is suppressed significantly when compared with that in the perfect area. The capability of EMCD at 1 nm spatial resolution enable us to correlate our experimental magnetic circular dichroism spectra from local defects with corresponding structural and chemical information recorded at the atomic scale, opening the door to experimental investigations of the relationship between atomic structure and magnetic properties of local defects in materials.

Reference

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