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Department of Physics & Astronomy

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X-ray magnetic circular dichroism study of oxide-based magnetic materials

The study of spintronics materials such as dilute magnetic semiconductors (DMSs) and multiferroics is one of the most attractive fields in science from the viewpoints of both academic research and applications. In order to clarify the origin of ferromagnetism of these spintronics, it is necessary to investigate the electronic structure. Here, we have investigated the electronic structure of spintronics materials using x-ray absorption spectroscopy (XAS) and x-ray magnetic circular dichroism (XMCD).

The first discovery of room-temperature ferromagnetism in Co-doped TiO_2 by Matsumoto et al. [1] has arisen great interest in the search for such materials and a number of studies have been carried-out to investigate whether the ferromagnetism is carrier-mediated or not [2-3], but the issue still remains controversial. XMCD at the Co $2p \rightarrow 3d$ absorption (Co $L_{2,3}$) edge is an ideal technique to clarify this issue because it is an element-specific magnetic probe. Our previous XMCD study has revealed that the ferromagnetism is not due to segregated Co metal clusters but is due to Co^{2+} ions in the TiO_2 matrix [4]. However, the XMCD signal intensities were an order of magnitude lower than that expected from the bulk magnetization [4]. We performed XAS and XMCD studies on rutile Co-doped TiO_2 by the surface-sensitive total electron yield (TEY) mode and the bulk-sensitive total fluorescence yield (TFY) mode and found that Co ions in the bulk indeed have a large moment of 0.8-2.2 μ_B /Co [5]. Then we extended the same approach to anatase Co-doped TiO_2 and studied the correlation between magnetism and transport properties.

Further we performed the XAS and the XMCD studies of (1-x) $BiFeO_3$-$x$$BiCoO_3$ (BFCO) thin films (where x = 0 to 0.30) grown on $LaAlO_3$(001) substrates using a chemical solution deposition technique. The XAS results indicated that the Fe ions were in the Fe^{3+} state and that the Co ions were in the Co^{3+} state. XMCD results showed that the Fe ions were in ferromagnetic state and the Co ions were in the paramagnetic state at room-temperature. The XMCD measurements also revealed that antiferromagnetically coupled Fe^{3+} ions were at the O_h and T_d sites. The magnetic moment of the Fe ions increased up to 20% Co content and after that it decreased. However, the Co magnetic moment was nearly independent of Co content unlike Fe, and the peak at 20% Co showed only a minor influence. The magnetization deduced from XMCD is larger than that obtained by SQUID measurements, indicates the enhancement of ferromagnetism within ~ 5 nm from the surface, probed by the total electron yield (TEY) method. (See references on next page)

Host:
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Friday, December 2, 2011
2:30 pm - Room 151, Jorgensen Hall

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