Recent status of HiSOR BL-14

Magnetic interaction intermediated through a monatomic insulating layer, studied by XMCD experiment and computational method

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HiSOR-BL14 is a soft X-ray beamline whose energy range is between 400 and 1200 eV, aimed at X-ray absorption spectroscopy and related dichroic experiments for transition metals and their compounds [1, 2]. In recent several years, we have especially devoted our activity to X-ray magnetic circular dichroism (XMCD) experiment, which is a powerful tool to study magnetic properties and to analyze the local magnetic moment element-specifically for magnetic layers grown on single crystal surfaces. To extract the intrinsic nature of magnetism without influence of oxidation or surface contamination, we have constructed an *in-situ* experiment system at HiSOR-BL14, where all experiments of a sample fabrication, characterization and XMCD measurements can be conducted under ultra-high vacuum (UHV) at the same time [3].

Magnetic tunnel junction (MTJ) is one of important magnetic layered structures related to device applications. Epitaxial MTJ with well-ordered interfaces shows high-performance in tunneling magnetic resistance (TMR) effect, since coherent tunneling between the magnetic electrode layers is realized with keeping orbital symmetry of the wave function of the tunneling electron. Epitaxial MTJ with an ultrathin burrier layer is a good solution compatible with both high-MR-ratio and high-speed-access, ensured by impedance low enough against minimized cross section in highly integrated TMR memory cell. Hexagonal boron nitride (h-BN) is one of ideal monolayers as candidate for the ultrathin burrier layer in TMR devices.

Essentially, magnetic state at the MTJ interface affects device performance in the TMR memory cell, and besides, interlayer magnetic interaction is crucial in the control of memory bit and exchange bias effect. We have focused on the interfacial and interlayer magnetic properties in the monatomic layers of Co/h-BN/Ni(111), Fe/h-BN/Ni(111) [4], and FeMn/h-BN/Ni(111), using our *in-situ* XMCD system. In all the cases, antiferromagnetic (AFM) coupling between both sides of magnetic layers were found through the monolayer of h-BN, and the AFM coupling energies were depending on magnetic elements of the top layer.

The electronic structure calculation is a powerful tool to know microscopic origin of specific magnetic and electronic properties emerge in artificial layers and interfaces [5]. We have adopted first principle calculation (VASP) for a realistic slab model corresponding to the ultrathin TMR structure of Co/h-BN/Ni(111). The computational analysis shows a magnetic interaction chain of spin-polarized bonding orbital plays essential role in the AFM coupling through a monatomic layer of h-BN.

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