$SrTiO_3$バリアを用いた(111)配向接合における大きなトンネル磁気抵抗効果

Large tunnel magnetoresistance in (111)-oriented junctions with a $SrTiO_3$ barrier

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High tunnel magnetoresistance (TMR) ratios are essential for all the applications of magnetic tunnel junctions (MTJs). While most previous studies have focused on (001)-oriented MTJs such as Fe/MgO/Fe(001) for obtaining high TMR ratios, our recent studies have addressed unconventional (111)-oriented MTJs with the stacking direction parallel to [111] directions of the ferromagnetic electrodes and the tunnel barrier [1,2]. The important advantage of such MTJs is that one can achieve large perpendicular magnetic anisotropy by using various fcc-based ferromagnets as electrodes of MTJs. Moreover, the (111) plane of the fcc structure is the close-packed plane with the lowest surface energy, indicating the feasibility of such MTJs. Our theoretical calculations have shown that the (111)-oriented MTJs with Co-based ferromagnets and MgO barrier have high TMR ratios, which is attributed to the interfacial resonant tunneling [1,2].

In this work, we theoretically investigate the TMR effect in novel (111)-oriented MTJs with a $SrTiO_3$ barrier, $X/SrTiO_3/X(111)$ (X = Co, Ni), shown in Fig. 1(a) [3]. On the basis of the ballistic transport theory, we calculate TMR ratios by using the first-principles calculation and the Landauer formula. It is found that both MTJs have high TMR ratios of ~ 500% for the Co-based MTJ and ~ 300% for the Ni-based MTJ. Since the in-plane lattice periodicity of $SrTiO_3$ is twice as long as that of fcc Co (Ni), the original band structures of fcc Co (Ni) are folded in the k_x-k_y plane corresponding to the *ab* plane of the MTJ cell. We reveal that such a band folding gives a half-metallic band structure in the Λ_1 state of Co (Ni) [Fig. 1(b)] and the coherent tunneling of the half-metallic Λ_1 state yields a high TMR ratio.

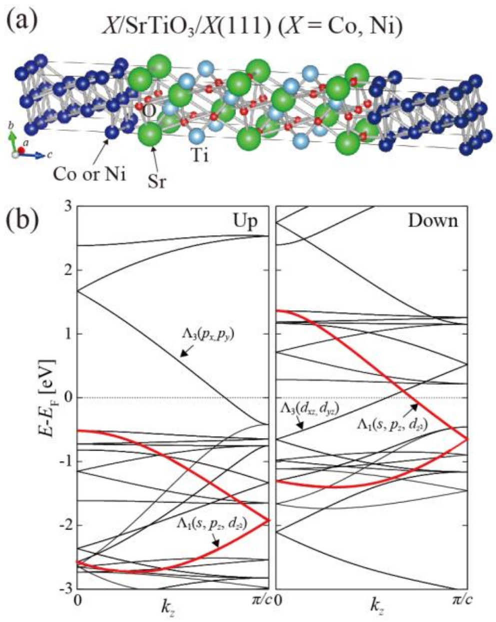

FIG. 1. (a) Supercell of $X/SrTiO_3/X(111)$ (X = Co, Ni). (b) Up- and Down-spin band structures along the Λ line of fcc Co for the unit cell with four atoms in each plane. From Ref. [3].

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