Influence of the multi-orbital hybridizations on the spin-to-charge conversion at the $LaAlO_3$ / $SrTiO_3$ interface

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The Rashba spin-orbit interaction (SOI) at material interfaces, which is caused by broken inversion symmetry, has attracted much attention for the realization of low-power-consumption non-volatile magnetic memory devices using spin-charge conversion. By the Rashba SOI, the spin degeneracy of the energy band is lifted, and the Fermi surface is split. In a two-dimensional electron gas (2DEG) with the Rashba SOI, it is known that an injected spin current is converted into a charge current. This phenomenon is called the inverse Edelstein effect (IEE), and the conversion efficiency of the IEE is called the inverse Edelstein length λ_{IEE}. In our previous study, we theoretically calculated the temperature dependence of the λ_{IEE} in the 2DEG at the $LaAlO_3$/$SrTiO_3$ (LAO/STO) interface, where Rashba SOI is large, and compared it with experimental results. We also calculated the band structure and the Fermi-energy E_F dependence of $j_c^{2D}/\delta s$, where j_c^{2D} is a two-dimensional charge-current density and δs is spin accumulation, as shown in Fig. 1(a) [1]. However, the cause of peaks of $j_c^{2D}/\delta s$ (large peaks are seen at 90 meV, 130 meV, and 225 meV from the conduction band bottom) has not been clarified yet.

To clarify the cause of each peak, we investigate the influence of the j_c^{2D} and δs separately. Figs. 1(b) and 1(c) show the E_F dependence of j_c^{2D} and δs. We can see that the j_c^{2D} (Fig. 1(b)) has peaks at the same energy (90 meV, 130 meV, and 225 meV) as those seen in Fig. 1(a). For further investigation, we calculate the j_c^{2D} separately for each band. Fig. 1(d) shows an example of our calculation for j_c^{2D} at E_F ranging from 80 meV to 95 meV. The j_c^{2D} originating from the d_{yz} band reaches a maximum at around 85 meV. This is probably due to the enhancement of Rashba splitting by hybridization between the d_{yz} band and first d_{xy} subband at around 85 meV, which we have shown in our previous study [1]. There have been only a few studies that analyzed the origin of the peaks in the spin-to-charge conversion efficiency considering the subband structures, and this result is expected to deepen our understanding of spin-to-charge conversion. In our presentation, we will discuss in detail the contribution of each band to peaks of $j_c^{2D}/\delta s$ at each energy (90 meV, 130 meV, and 225 meV). This work was partly supported by Grants-in Aid Scientific Research, the CREST program of JST, and Spintronics Research Network of Japan.

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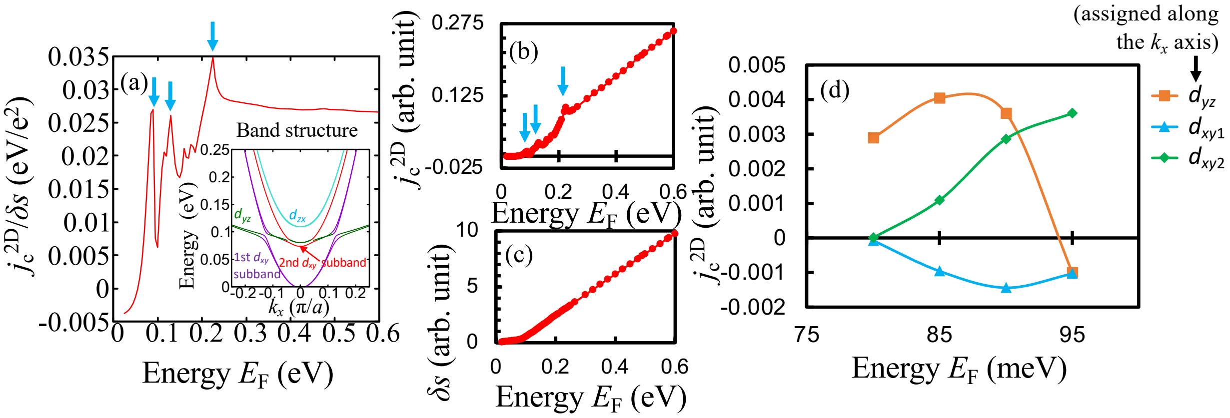

Fig. 1. (a) E_F dependence of $j_c^{2D}/\delta s$ and the band structure. (b) E_F dependence of j_c^{2D}. (c) E_F dependence of δs. (d) E_F dependence of j_c^{2D} for each band at an energy ranging from 80 meV to 95 meV. The orange, light blue, and green curves represent the contributions of the d_{yz} band, first d_{xy} subband, and second d_{xy} subband, respectively.

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