Spin-momentum locking and spin-charge conversion in ultra-thin epitaxial $Bi_{1-x}Sb_x$ topological insulator

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Very efficient spin current to charge current conversion is reported in ultra-thin topological BiSb films (down to 2.5 nm), where confinement effects become predominant. The films were epitaxially grown on Si [111] substrates [1]. The surface state robustness was first confirmed by ARPES, indicating no overlap between the topological 2D states of opposite surfaces. This is consistent with our tight-binding calculations, which indicate that the surface states are strongly confined, over a few bilayers, at the interface. Spin resolved ARPES reveals their spin-momentum locking (Fig. 1 left) [2].

The spin to charge conversion was then measured by ultra-short laser-pulse induced THz emission spectroscopy in Co/BiSb layers (Fig. 1 right). The conversion efficiency is larger than in our best optimized Co/Pt structure [2]. Our results show that the conversion mostly occurs, through the inverse Edelstein effect, in the surface states, with little or no contribution from bulk states. We attribute this result, in part, to the large bandgap increase (several hundred of meV) due to confinement in ultra-thin films.

These results indicate that ultra-thin BiSb films, although less investigated than the $(Bi,Sb)_2(Te,Se)_3$ family, are of great interest to spintronics applications.

[1] L. Baringthon et al., Phys. Rev. Mat., 6 (2022) 074204
[2] E. Rongione et al., submitted (2022)

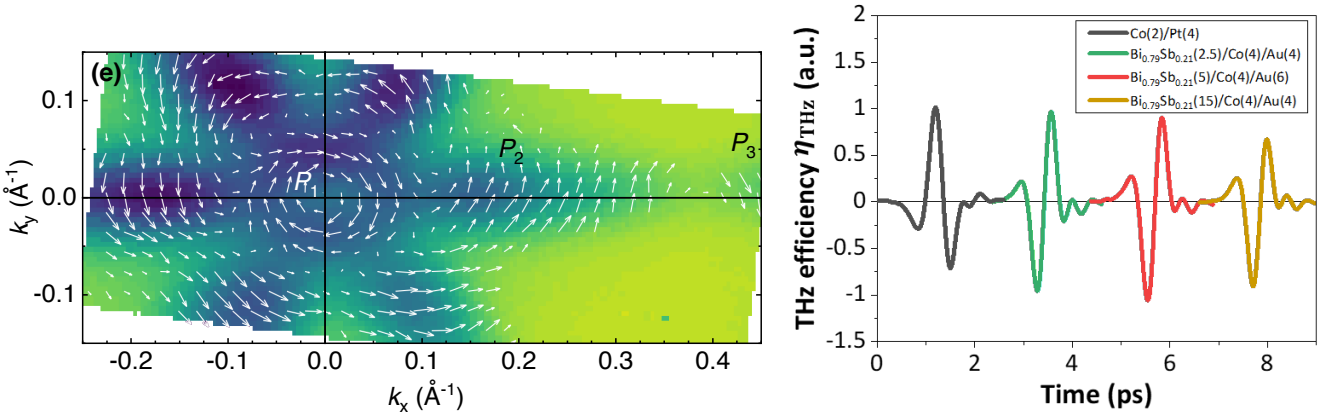

Figure 1: (left) Color map representing the measured ARPES intensity close to the Fermi energy of a 5 nm thick $Bi_{0.85}Sb_{0.15}$ film grown on Si [111]. The dark regions correspond to the surface state DOS. The arrows represent the measured spin polarization direction and amplitude at room temperature. (right) Time-resolved THz emission signal (corrected for absorption) from BiSb layers with thicknesses 2.5, 5 and 15 nm, after ultra-short laser-pulse induced demagnetization of an adjacent Co layer. This signal results from the spin current to charge current conversion. For comparison, the signal obtained from an optimized Co/Pt layer is given.