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Ultrafast modulation of Rashba coupling in ferroelectric α-GeTe(111) observed through trARPES and momentum microscopy

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Intense femtosecond (fs) light pulses are a powerful tool for controlling the physical properties of solids, and for inducing enhanced and emergent phenomena inaccessible at equilibrium. In the area of spintronics, Rashba materials have appeared as an ideal playground for efficient spin-to-charge conversion in prototype devices via the inverse spin Hall and inverse Rashba-Edelstein effects. Coupling with fs light pulses therefore potentially allows for ultrafast read/write processes to be performed, demanding an exploration of ferroelectric control on these timescales. A material with particular promise in this direction is α-GeTe(111), a non-centrosymmetric ferroelectric (FE) semiconductor. It displays a giant FE distortion below 700 K, which results in spin-polarized bulk and surface states with the largest Rashba parameter so far reported. Furthermore, its room temperature ferroelectricity has recently been demonstrated as providing a route towards a new type of highly energy-efficient non-volatile memory device based on switchable polarization. Using fs light pulses to manipulate the FE polarization state in GeTe thus presents exciting opportunities to dramatically enhance the performance of future spintronics devices.

Here, I will present our recent results probing the room temperature dynamics of the electronic band structure of α-GeTe(111) [1]. To do so we employ time- and angle-resolved photoemission spectroscopy (trARPES) using both a standard 2D detector and a recently developed momentum microscope (MM). This combination allows us to acquire simultaneous dynamics throughout the full Brillouin zone, and to zoom in on particular regions of interest with very high counting statistics, fully exploiting our 500 kHz high-harmonic source at 21 eV. Our experiments allow us to track the electronic intra- and inter valley scattering pathways of states above the Fermi level throughout the Brillouin zone and to map their distribution in momentum space. Meanwhile, in the states below the Fermi level we find a transient modulation of the bulk Rashba splitting corresponding to a 13% enhancement of the FE lattice distortion. Our analysis reveals that the effective change of the Rashba coupling is mediated on the fs timescale by a transient surface photovoltage, which results in the delayed displacive excitation of a phonon along the FE distortion direction. This may open the door to the FE polarization control in other semiconducting materials, including at the 2D limit.

[1] Kremer et al., Field-induced ultrafast modulation of Rashba coupling at room temperature in ferroelectric α-GeTe(111), in press at Nature Communications, arXiv:2204.11630 (2022)

Für diese Zeit steht eine Kinderbetreuung nach vorheriger Anmeldung zur Verfügung.

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