

New materials for opto-electronic and spintronic devices from understanding spin relaxation in topological insulators

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Scientists have gained insights that will aid development of new materials for opto-electronic and spintronic devices by understanding spin relaxation in topological insulators.

A European collaboration, including UK scientists from the Central

Laser Facility and Diamond Light Source, has successfully gained new insights into the excited state spin dynamics of topological insulators. Using a technique known as Spin, Time and Angle Resolved Spectroscopies (STARS), on the ultrafast infrared lasers available on the Nanoscience beamline (I06), the team reports on the spin-dependent scattering between bulk and [surface states](#) in the archetypal topological insulator Bi_2Se_3 . The results were published on the 4th March 2015 in the journal *Physical Review Letters*.

Dr. Cephise Cacho, from STFC's Central Laser Facility, explains the research, "There is currently wide interest in the idea of being able to optically induce and control a spin-polarised current in spintronic devices. However, we know that there is a very complex interplay between the electrons photoexcited into the spin-polarized surface states and the bulk spin-degenerate states. The out-of-equilibrium electronic and spin structure of topological insulators has reveal some novel dynamics at work in our study."

The collaboration, involved researchers from academic institutes and facilities across 8 European countries, who spent 6 months preparing for these experiments at Diamond and then over a month taking measurements in Nanoscience beamline's new laser cabin. The experiments revealed the existence of a surface resonance state in the second bulk band gap which significantly affected the relaxtion of the different spin channels. Furthermore, the experimental results were fully explained using relativistic ab initio spin-resolved photoemission calculations.

Dr. Cacho continues "We have shown that the newly discovered surface resonance state plays a crucial role in the ultrafast dynamics of topological insulators and acts as a bottleneck for the interaction between the topologically protected surface state and the bulk conduction band. We also found that the spin-polarization dynamics in momentum space

show that these states display macroscopically different temperatures and, more importantly, different cooling rates over several picoseconds. This research is of fundamental importance for future opto-spintronic devices, since the bulk states could be responsible for effects such as a net photogalvanic current."

Prof. Sarnjeet Dhesi adds "On beamline I06 we have used the femtosecond lasers to understand ultrafast spin-polarised dynamics in [topological insulators](#) in this study. The lasers are also used in a programme of study involving Resonant Soft X-ray Diffraction which we have developed as an ultrafast probe of strongly-correlated systems at Diamond and X-Ray Free Electron Lasers."

More information: "Momentum-Resolved Spin Dynamics of Bulk and Surface Excited States in the Topological Insulator Bi_2Se_3 " Phys. Rev. Lett. 114, 097401 – Published 4 March 2015.
journals.aps.org/prl/abstract/...ysRevLett.114.097401

Provided by Diamond Light Source

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