Spintronics: Deciphering a material for future electronics

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Topological insulators are the key to future spintronics technologies. EPFL scientists have unraveled how these strange materials work, overcoming one of the biggest obstacles on the way to next-generation applications.

Spintronics is an emerging field of electronics, where instead of using the charge of electrons, devices work by manipulating electron spin. Already tested in hard drives, spintronics are poised to replace current information technology, providing increased data transfer speeds, processing power, memory density and storage capacity. Controlling electron spin can be achieved with topological insulators; a novel class of materials that behave as insulators on the inside, but are highly conductive on their surfaces. However, it has been unclear how exactly a normal material can become a topological insulator, and also how to implement them for real technological impact. Publishing in *Physical Review Letters*, EPFL scientists offer solutions to both problems by studying the spin structure of few atoms-thick films of a common topological insulator.

Future electronics will most likely utilize an intrinsic property of electrons called spin. This spin can take either of two possible states: "up" or "down", which in a classical picture corresponds to a clockwise or counterclockwise rotation of the electron around its axis. The electron spin can also be viewed as an extremely small magnetic field surrounding the electron. The field of spintronics aims to exploit spin in order to develop a new era of technological applications. Information technology in particular stands to gain the most, as spintronics can offer considerably higher overall computing speeds and storage capacities at lower power consumption.

Just like conventional electronics requires switching between high and low current states, spintronics require the control of electron spin states and switch between "up" and "down". Recent interest has focused on topological insulators, which can conduct spin-polarised electrons on their surface while their inner bulk acts as an insulator. However, manufacturing and implementing topological insulators has been limited because of technical limitations and because the formation of their unusual properties has not been entirely clear.

An international team of researchers led by Hugo Dil at EPFL has now shown how spin-polarised electrons evolves on the surface of atomically flat bismuth-selenide topological insulator films no more than 30 atoms thick. The researchers used a spectroscopic technique called SARPES, which allowed them to determine the different spin states of electrons travelling across the conducting surface of a topological insulator. They found that the ability of the topological insulator to control the electron spin depends on its interface to the substrate and, surprisingly, not on the film thickness.

The team's findings show that tuning the chemical make-up of a topological insulator can directly manipulate the spin of electrons flowing across its surface. The discovery not only contributes to the understanding of the function of topological insulators, but also provides a fundamental means of designing spintronics devices in the future.

More information: The full study is available here: arxiv.org/pdf/1307.5485.pdf

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