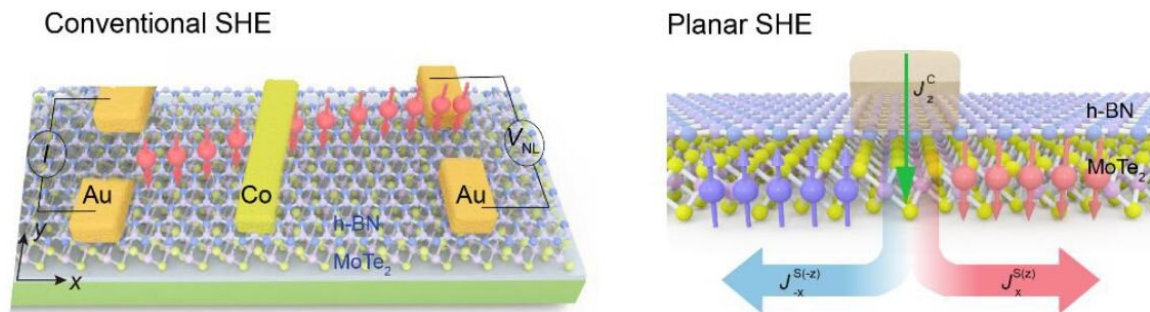


# Thinning down Weyl semimetals provides a new twist to spintronics

February 4 2020



Schematic showing (left) conventional spin Hall effect (SHE) in which the charge current along the y-axis generates a spin current along the x-axis (with spin polarisation indicated by the red ball with arrow). (Right) Newly observed planar SHE in MoTe<sub>2</sub> converting charge current into long-lived spin current. The spin polarisation and charge current are collinear, instead of orthogonal. Credit: National University of Singapore

Spin is a fundamental quantum property that influences a range of physical and chemical phenomena associated with it. Using a material's spin property to carry current has applications in transferring data at much higher speed, for example, and achieves better energy efficiency than traditional devices that rely on electrical charges. However, this requires a material that can generate long-lived pure spin current with high efficiency.

A team led by Prof LOH Kian Ping, Department of Chemistry and Centre for Advanced 2-D Materials, NUS, has identified one such promising candidate in the form of few-layer thin semimetal molybdenum ditelluride ( $\text{MoTe}_2$ ). A semimetal is a material with a very small overlap between the bottom of the conduction band and the top of the valence band. It has material properties that are intermediate between those of metals and semiconductors.

The team relied on the so-called intrinsic [spin](#) Hall effect (SHE) in  $\text{MoTe}_2$ , which converts charge current to pure spin current without a strong magnetic field or complicated excitation methods. In conventional materials, SHE suffers from two limitations. One is the trade-off between the charge-spin conversion efficiency and the spin diffusion length. Another is the geometrical constraint that requires the flow of charge current, spin current and spin polarization to be mutually orthogonal to each other. The latter limits the [device](#) configurations where spin current can be used to switch the orientation of a magnetic layer in magnetic devices.

Prof Loh said, "We discovered that both limitations can be overcome by lowering the symmetry of semimetal  $\text{MoTe}_2$  crystal. In practice, this simply requires the  $\text{MoTe}_2$  crystal to be thinned to a few-layer thickness."

Dr. SONG Peng, the first author of the paper, obtained atomically thin samples using the scotch-tape exfoliation method and fabricated the devices for studying charge-to-spin conversion. By using a non-magnetic electrode to inject charges into the sample, he was able to generate [pure spin current](#) and measure its diffusion length in the material. A charge-spin conversion efficiency of about 30% and spin diffusion length of about 2  $\mu\text{m}$  was obtained. The combination of both characteristics is very rare and has not been observed in other materials, including platinum and gallium arsenide.

The team explained that the innovation lies in the symmetry breaking along with reduction of crystal dimensionality. The [spin-orbit coupling](#), which is responsible for the spin current, exhibits unusual behavior in atomically thin MoTe<sub>2</sub>. Apart from generating spin current efficiently, it also helps the spin current propagate a distance of 2  $\mu\text{m}$ , which is much longer than the spin diffusion length (about 10 nm) found in commonly studied spin Hall metals, such as platinum and tungsten.

In addition, the team identified a new form of SHE, which they called Planar SHE to denote the fact that spin polarization and charge current can be collinear instead of orthogonal. Reduction of the crystal symmetry is responsible for generating planar SHE. Such an effect can be applied to switch magnetization in magnetic tunneling junctions using the spin transfer torque effect.

"Our study not only identified a promising material for future energy efficient devices, but also uncovers the concept that symmetry reduction can be a powerful strategy to manipulate spin-orbit related effects," added Prof Loh.

Next, the team plans to incorporate this material into functional devices, such as random access memory, for potential applications in the real world.

The study is published in *Nature Materials*.

**More information:** Peng Song et al. Coexistence of large conventional and planar spin Hall effect with long spin diffusion length in a low-symmetry semimetal at room temperature, *Nature Materials* (2020). [DOI: 10.1038/s41563-019-0600-4](https://doi.org/10.1038/s41563-019-0600-4)

Provided by National University of Singapore

Citation: Thinning down Weyl semimetals provides a new twist to spintronics (2020, February 4)  
retrieved 5 April 2024 from

<https://phys.org/news/2020-02-thinning-weyl-semimetals-spintronics.html>

<p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p>
--