Important progress for spintronics: A spin amplifier to be used in room temperature

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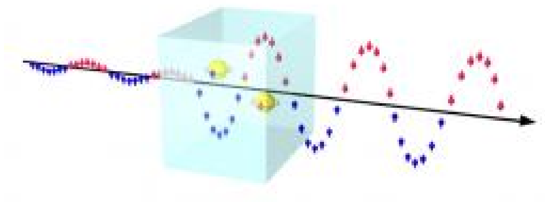

A schematic picture of the defect-engineered spin amplifier demonstrated in this work. The wave pattern symbolizes the time variation of the spin signal, namely the difference between the numbers of spin-up and spin-down electrons. The red and blue arrows represent the period with more spin-up and spin-down electrons, respectively. The amplitude of the wave reflects the strength of the spin signal, which is weak before entering the spin amplifier but becomes stronger when exiting. The defects that have enabled the spin-amplification functionality of a non-magnetic semiconductor are indicated by the yellow balls, each with a spin-polarized localized electron (indicated by the red and blue arrows). The spin direction of this localized electron rapidly follows the sign of the input spin signal, which serves to only attract and remove the incoming electrons with an undesired spin orientation. This leads to a significant enhancement in the spin polarization of the electrons passing the spin amplifier, giving rise to a strongly amplified output spin signal that has truthfully cloned the exactly same time-varying function and thus the spin-encoded information of the input spin signal. Credit: Weimin Chen/*Adv. Mater.* 2012, DOI 10.1002/adma.20120597

A fundamental cornerstone for spintronics that has been missing up until now has been constructed by a team of physicists at Linköping University in Sweden. It's the world's first spin amplifier that can be used at room temperature.

Great hopes have been placed on spintronics as the next big paradigm shift in the field of electronics. Spintronics combines microelectronics, which is built on the charge of electrons, with the magnetism that originates in the electrons' spin. This lays the foundation for entirely new applications that fire the imagination. The word "spin" aims at describing how electrons spin around, much like how the Earth spins on its own axis.

But turning theory into practice requires amplifying these very weak signals. Instead of transistors, rectifiers, and so on, the building blocks of spintronics will be formed by things like spin filters, spin amplifiers, and spin detectors. Through regulating and controlling electron spin, it will be possible to store data more densely and process it many times faster – and with greater energy efficiency – than today's technology.

In 2009, an LiU group from the Department of Functional Electronic Material, led by Professor Weimin Chen, presented a new type of spin filter that works at room temperature. The filter lets through electrons that have the desired spin direction, screening out the others. This function is crucial for constructing new types of components such as spin diodes and spin lasers.

Now the same group, in collaboration with colleagues from Germany and the United States, has published an article in the highly-ranked journal Advanced Materials, where they present an effective spin amplifier based on a non-magnetic semiconductor. The amplification occurs through deliberate defects in the form of extra gallium atoms introduced into an alloy of gallium, indium, nitrogen and arsenic.

A component of this kind can be set anywhere along a path of spin transport to amplify signals that have weakened along the way. By combining this with a spin detector, it may be possible to read even extremely weak spin signals.

"It's an advance that blazes a trail for a solution to the problem of controlling and detecting electron spin at room temperature, which is a prerequisite for the breakthrough of spintronics," says Weimin Chen.

More information: Room-temperature electron spin amplifier based on Ga(In)NAs alloys by Y. Puttisong, I.A. Buyanova, A.J. Ptak, C.W. Tu, L. Geelhaar, H. Richert and W.M. Chen. *Advanced Materials* online 26 October 2012. DOI 10.1002/adma.20120597

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