Could better spin injection lead to a quantum information device?

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One of the more promising types of materials for use in spintronics today is the class of metal alloys known as Heusler alloys. These alloys are named after a German engineer, and might be useful in technology in which electron quantum spin states are used to enhance electronic devices. Additionally, Heusler alloys may have an effect in quantum memory processing and telecommunications.

Unfortunately, Stuart Holmes tells *PhysOrg.com*, Heusler alloys can be difficult to work with. “These are theoretically useful,” he explains, “but in practice they are difficult to control.” But by studying the make-up and properties of these alloys – their stoichiometry – it may be possible to improve the work that can be done with them.

Holmes, a professor at the University of Cambridge, is one of several scientists working on better understanding spin injector stoichiometry. He is part of a team comprised of members at the University of Cambridge and at the Technical University of Denmark, with input from the company Toshiba, that has recently been able to demonstrate increased spin injection efficiency. Their work is published in *Applied Physics Letters*: “Spin injection from Co_2MnGa into an InGaAs quantum well.”

“The actual subject area we are studying is for a quantum information device,” Holmes says. “But there are other uses this work could potentially have beyond our field of research in quantum information.”

Holmes explains that he and his colleagues took spin information from the thin film Heusler alloy of cobalt, magnesium and gallium and transferred it into a quantum well of semiconducting indium gallium arsenide. The Co_2MnGa is a half metal, and it is required to interface coherently with the semiconductor. “We apply voltage to the device, and a spin polarized current is injected into the semiconductor. If it is 100 percent polarized, the photons coming out are polarized, and those can be used in quantum communications.”

Similar experiments have been done before, Holmes acknowledges, but this one shows some increased efficiency. “We have some earlier work where the efficiency was only 10 percent,” he says. “So with the efficiency at around 22 percent, we have doubled it.”

Most of the increased efficiency comes from a better study of the properties of the materials in question. “It comes down to controlling the stoichiometry,” Holmes explains. “We’ve understood how to control it, and we’ve been able to find a material that provides good spin injection.”

Holmes does admit that there is still work to be done. “We need to study the best interface between the half metal and the semiconductor. We need to better understand how it works.” He also points out that there might be other materials that would be “more suitable” for the work, and he says that he and his peers are considering using a tunnel barrier between the half metal and the semiconductor in order to increase the spin injection frequency. “We also plan to look at binary options,” he says. Right now, with the grouping of three in the alloy, it is a little harder to control than it would be with two.

But for now, this demonstration is a continued step in the right direction. “We have been able to quantitatively assess the role of spin injection stoichiometry,” Holmes says, “and we have been able to provide an increase in efficiency.”