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Layers of magnetic and non-magnetic materials are used in the read heads of computer hard drives.

Materials science

Bringing magnetism to gold

The magnetic alignment of iron carries further into an adjacent non-magnetic gold layer than anticipated

Many physical phenomena can arise at the interface between two different materials, and they are often important for many applications. In computer hard drives, the electrical resistance of a non-magnetic material that is surrounded by magnetic layers is very sensitive to external magnetic fields, which is used to read the magnetic information on the hard drive.

Studying related magnetic structures, Nobuyoshi Hosoito and colleagues from the NAIST Graduate School of Materials Science, the Japan Synchrotron Radiation Institute in Sayo and the Nara National College of Technology have discovered that the magnetic polarization can extend further into the non-magnetic layer than previously anticipated[1]. "We have shown that gold atoms within a few nanometres from the interface with an iron layer behave more like a ferromagnet than a non-magnet," says Hosoito.

The magnetic information carried by elementary particles, such as the electron, is known as their 'spin'. Whereas conventional electronic devices, such as transistors, make use of the electrical charge of an electron, researchers are working on devices that use the spin instead, because this offers benefits such as a potentially lower energy consumption. In particular, the combination of magnetic and non-magnetic materials enables new avenues for controlling magnetic properties.

An important aspect of these devices is to understand how far the magnetism of a magnet extends into an adjacent non-magnet — in this case, that of iron into a layer of gold. This is possible using resonant X-ray magnetic scattering, which probes the relative orientation of the electron spins in the atomic states of gold with high precision.

The expectation was that, away from the interface with the iron alignment, the spins within the gold layer drops off rapidly towards the random orientations of a non-magnet. However, the measurements show that the spin alignment extends further into the gold than expected. This is due to the enhancements from the interface between the iron and the gold, explains Hosoito. "Electrons approaching this interface are reflected differently according to the orientation of their spins. This creates a polarization."

The creation of an enhanced magnetic polarization inside non-magnets could lead to new fundamental physical phenomena, where the aligned spins inside the non-magnet can interact with other effects that typically do not exist in magnetic materials, such as superconductivity, to achieve new functionalities. More practically, in technical devices such as computer hard drives, the manipulation of magnetic fields by complex magnetic/non-magnetic structures could deliver its own advantages for the manipulation of magnetism in enhanced storage devices.

Reference

1. Hosoito, N., Ohkochi, T., Kodama, K. & Suzuki, M. Charge and induced magnetic structures of Au layers in Fe/Au bilayer and Fe/Au/Fe trilayer films by resonant X-ray magnetic reflectivity at the Au L_3 absorption edge. *Journal of the Physical Society of Japan* **83,** 024704 (2014).

More information about the group's research can be found at the Nanostructure Magnetism Laboratory webpage:
http://mswebs.naist.jp/LABs/hosoito/English/English.html