Magnetoresistance ratio enhancement in Heusler-based alloy

December 18 2018

Magnetic field sensors can enhance applications that require efficient electric energy management. Improving magnetic field sensors below the picoTesla range could enable a technique to measure brain activity at room temperature with millisecond resolution—called magnetic encephalography—without superconducting quantum interference device (SQUID) technology, which requires cryogenic temperatures to work.

A group of researchers from Japan's National Institute of Materials Science at the University of Tsukuba and LG Japan Lab Inc. explored enhancing the magnetoresistance ratio in a current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) device by using a half-metallic Heusler CoFeAl0.5Si0.5 (CFAS) alloy. The alloy has 100 percent spin-polarized conduction electrons, which enables very high spin-asymmetry of electron scattering and results in a large magnetoresistance ratio. They report their findings in the *Journal of Applied Physics*.

Magnetoresistance—a variation of electrical resistance in response to an externally applied magnetic field—is important for all magnetic field sensor applications. To increase the sensitivity of magnetic field sensors, their magnetoresistance ratio (a value defined as electrical resistance change against magnetic field or magnetization) must first be increased.

"We were able to demonstrate further enhancement of the magnetoresistance ratio by making multilayer stacks of CFAS and silver

(Ag)," said Yuya Sakuraba, leader of the Magnet Materials Group at NIMS. "By precisely controlling the interfacial roughness of the multilayers, we obtained antiparallel interlayer exchange coupling between each of the CFAS layers, up to six, and achieved not only a high magnetoresistance ratio but also high linearity of resistance change against the magnetic field."

Previous studies demonstrated that half-metallic Heusler alloys are well suited to enhance the magnetoresistance ratio in CPP-GMR devices. "Heusler-based alloys are expected to be the next-generation read head for hard disk drives with high areal recording density over 2 terabits per square inch," Sakuraba said.

"And our work has demonstrated that further enhancement of the magnetoresistance ratio is possible by creating a multilayer structure, which now really opens up the potential of Heusler-based CPP-GMR for highly sensitive magnetic field sensor applications," Sakuraba went on to explain.

The researchers fabricated a fully expitaxial device on a single crystalline magnesium oxide (MgO) substrate. If a similar property can be obtained in a polycrystalline device, it may become a candidate for a new magnetic field sensor with a greater sensitivity than a conventional Hall sensor or tunnel magnetoresistancesensor.

More information: T. Shiroyama et al. High magnetic field sensitivity in anti-ferromagnetically coupled 001-epitaxial [Co2Fe(Al0.5Si0.5)/Ag]N multilayers, *Journal of Applied Physics* (2018). DOI: 10.1063/1.5048931

Provided by American Institute of Physics