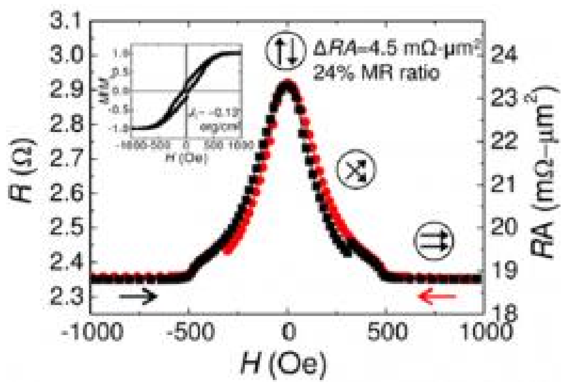
# Scissors-type trilayer giant magnetoresistive sensor using heusler alloy ferromagnet

November 30 2011




Resistance vs magnetic field of the Co2Fe(Al0.5Si0.5) (4 nm)/Ag(2 nm)/ Co2Fe(Al0.5Si0.5) (4 nm) trilayer CPP-GMR device measured at room temperature and the schematic "scissors-type" magnetization configuration of the two Co2Fe(Al0.5Si0.5) free layers. Inset is the magnetization curve of the unpatterned trilayer film.

Japanese researchers have demonstrated a scissors-type trilayer magnetoresistance device that is promising for narrow readers of ultra-high density hard disk drives (HDD). This device uses an antiferromagnetic interlayer exchange coupling of two Heusler alloy ferromagnetic (FM) layers separated by a thin silver layer. Since the magnetization of the two FM layers rotate around each other like scissors due to the antiferromagnetic coupling, the device is called a scissor-type MR sensor.

To obtain high MR outputs, a highly spin-polarized cobalt-based Heusler alloy is used for the FM layers of the tri-layer current-perpendicular-to-plane giant magnetoresistive device (CPP-GMR). The total device thickness of the scissors-type sensor is only 10 nm, which is less than half of that needed for the recording density of 2 Tera bit per square inch (Tbpsi). Thus, it is considered promising as a narrow reader for the next generation ultra-high density hard disk drives (HDD) with the areal density exceeding 2 Tbpsi.

In the current HDDs with an areal density of 700 Gbpsi, tunneling magnetoresistive (TMR) sensors are used as read heads. To achieve a recording density exceeding 2 Tbpsi in the future, the bit size of the magnetic information must be reduced to 20 nm. There are three technical requirements in the read sensors for a recording density exceeding 2 Tbpsi: large magnetoresistive outputs, low device resistance, and thin device thickness. In the currently-used TMR devices, a high magnetoresistive output can be achieved; however, the reduction of device resistance to a required level is difficult since a thin insulator layer must be used to separate the two ferromagnetic layers. Therefore, current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices using a metallic spacer layer is considered as a replacement for the TMR devices in future high density HDDs due to their intrinsically low device resistance. Since bit resolution is determined by the total thickness of the GMR spin valve devices made of multiple thin film layers, a reduction in the total thickness of the GMR spin valves is another technical challenge for the magnetic recording industry

A scissors-type magnetoresistive device using an antiferromagnetic exchange interlayer coupling between two FM layers separated by a nonferromagnetic spacer has been proposed as a potential narrow read sensor for high density recording. Since the magnetizations of the two FM layers are expected to rotate around each other like scissors, the antiferromagnetically exchange coupled tri-layer structure was proposed as a "scissor-type" MR sensor. However, there have not been any experimental demonstrations of such a scissors-type trilayer MR sensor with large MR outputs until now.

In this work, Dr. Nakatani and his collaborators observed an antiferromagnetic (AFM) interlayer exchange coupling (IEC) between two Co2Fe(Al0.5Si0.5) Heusler alloy ferromagnetic layers separated by a 2 nmAg spacer layer. This is the first observation of an antiferromagnetic interlayer exchange coupling in Heusler alloy FM layers. Using the AFM coupled trilayer, they demonstrated a scissors-type trilayer CPP-GMR device with a relatively large magnetoresistive output of ΔRA of 4.5 mΩμm2 and a MR ratio of 24%. Since the anti-ferromagnetic exchange coupling between the two ferromagnetic layers is realized in the tri-layer structure of two 4 nm FM layers and a 2 nm Ag layer, the total device thickness is only 10 nm, which is less than half of the required thickness for the 2 Tbps areal density; thus the tri-layer sensor is considered to be promising for future applications of ultrahigh density HDDs. The MR output was approximately 4 times larger than that reported for the current-in-plane scissor type device using a standard FM alloy.

**More information:** This result was published in the October 31 issue of *Applied Physics Letters*, 99, 182505 (2011), dx.doi.org/10.1063/1.3657409

Provided by National Institute for Materials Science