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Novel magnetic nanofilms

An international team of researchers has made a novel laminate oxide nanostructure that may suit high-frequency micromagnetic devices, such as thin film inductors, transformers and flux-gate sensors. The material, which consists of cobalt, iron, hafnium and oxygen, was synthesized using RF sputtering techniques and has excellent soft magnetic properties as well as high electrical resistivity.

Magnetic thin films are widely used for a large number of technology applications, including sensors and media for magnetic recording and in the automotive and aerospace industries. They are also one of the most important tools for preparing multifunctional materials.

Recently there has been an emerging demand for magnetic thin films in high-frequency applications, such as in magnetic recording write-heads, soft underlayers for "perpendicular" recording media and thin-film wireless inductor cores. However, these applications need thin films with high electrical resistivity (to minimize energy loss due to eddy currents), a large saturation magnetization and a so-called hard-axis anisotropy field to increase the magnetic switching capacity at high frequencies. Until now, however, most of the materials proposed have had low electrical resistivity and are unable to work in the technologically important gigahertz frequency range.

Now, an international team of scientists, including Manh-Huong Phan of Bristol University in the UK, Nguyen Duy Ha of Leiden University in the Netherlands and Chong Oh Kim of Chungnam National University in Korea, may have come up with a solution to the problem. The researchers have shown that they can make single-layer magnetic oxide thin films from cobalt iron hafnium oxide (CoFeHfO) using an RF sputtering technique.

Using magnetic hysteresis measurements, the team has shown that the nanostructure has excellent magnetic properties with a large saturation magnetization of 18–21 kG and a large hard-axis anisotropy field of 30–84 Oe. Moreover, the material has a high electrical resistivity of 1400–3600 μΩ. According to Phan and co-workers, these properties make

CoFeHfO an ideal candidate for high-frequency micromagnetic devices.

The team has also revealed that the laminate structure, which consists of nanocrystalline α-Fe(Co)-rich layers separated by amorphous HfO_2-rich layers, can be considered as a [Fe (Co)-rich/HfO2-rich]$_n$ multilayer, where "exchange coupling" of Fe–Fe(Co) takes place between two neighbouring ferromagnetic layers through an insulating HfO_2-rich amorphous layer. This indicates that CoFeHfO is itself a "tunnelling multijunction", which means that it could be developed for use in advanced spintronic applications, where the spin of the electron is exploited as well as its charge. "Since the CoFeHfO thin films are insensitive to oxygen at interfaces, they can ideally be used as free layers for the fabrication of spin-dependent tunnelling junctions and as electrode layers for tunnelling magnetoresistive (TMR) junction applications," Phan told *nanotechweb.org*.

Phan added that the RF sputtering technique employed in this new work could also help to design other smart, nanostructural magnetic thin-film materials. The method allows a high degree of control over the thin film's growth, allowing its chemical composition, and so its properties, to be optimized.

And if all this was not enough, the team has also discovered that the CoFeHfO thin films show a giant magnetoimpedance (GMI) effect. This means that the material could find use in magnetic recording heads using GMI sensing technology.

The researchers published their work in *Nanotechnology*.

About the author

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