Study of switching behavior in differential dual spin valves reveals the role of interlayer couplings

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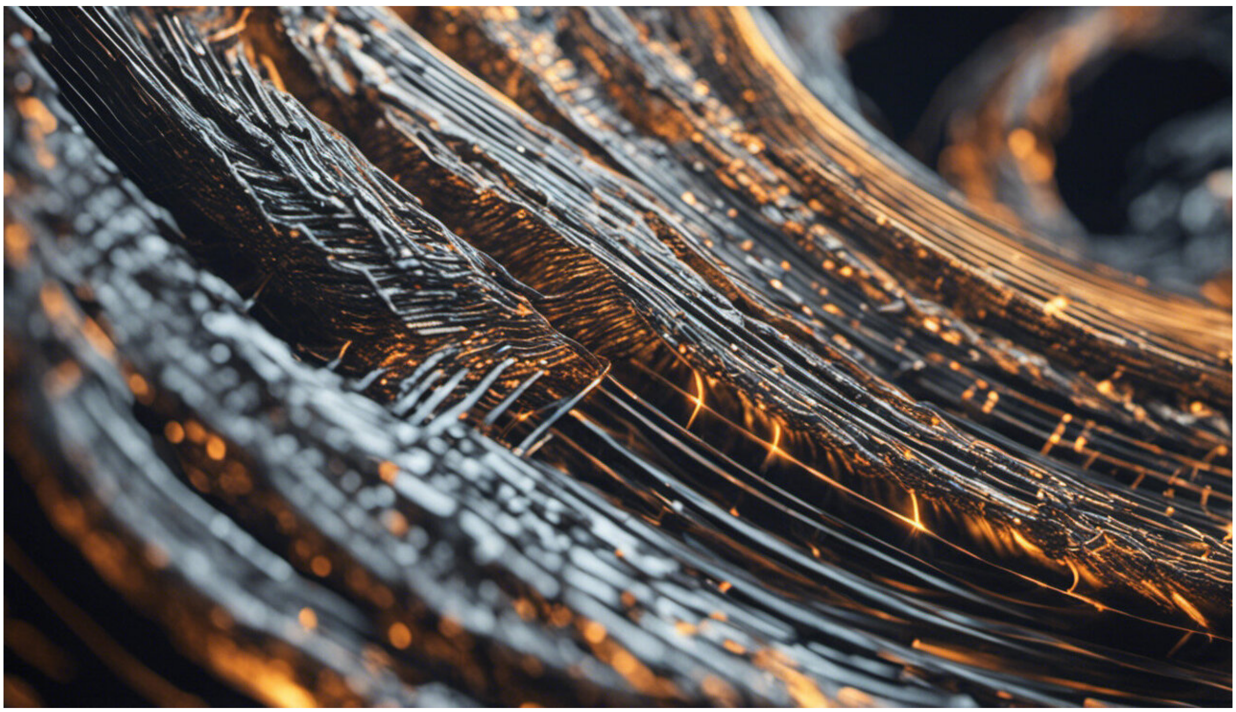

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Spin valves are essential building blocks in the magnetic sensors of read heads in hard disk drives. They consist of two magnetic layers separated by a non-magnetic layer and act as valves for electrons depending on the relative alignment of the magnetization (spin) in the magnetic layers.

With the continuous push to boost the storage density of disk drives, it has become increasingly important to shield each individual sensor from the magnetic flux of adjacent bits. However, the current approach of placing the read sensor between two magnetic shields limits the resolution with which information can be packed.

To circumvent this issue, a read sensor using a 'differential dual spin valve' (DDSV) was previously proposed by Guchang Han and co-workers at the A*STAR Data Storage Institute. Based on two spin valves separated by a gap layer, it is not influenced by uniform magnetic fields (unlike single spin valve read sensors) but on field gradients. As Han explains, the packing resolution is thereby no longer limited by the magnetic shield-to-shield spacing, but by the thickness of the two active layers in the spin valves (called free layers) and the gap layer separating them.

In a significant step in understanding how the reading performance of DDSVs is affected by further downscaling of the device dimensions, Han and his colleagues have now systematically studied the magnetic interactions between the free layers as a function of their thicknesses as well as the gap layer material and thickness.

“There are mainly two types of interlayer interactions between the two free layers,” says Han. One is a magnetostatic interaction, which propagates along the edges of the device. The other is mediated through the gap layer by either free electrons (the so-called RKKY interaction) or magnetic poles formed at the rough interfaces between the gap and free layers (Néel coupling).

While the Néel coupling is always ferromagnetic, thus favoring parallel alignment of the magnetizations in the free layers, the RKKY interaction can be either ferro- or antiferromagnetic , depending on the gap layer thickness and material. “From a DDSV working principle, it is desirable to have the two free layers couple antiferromagnetically," notes Han.

For patterned DDSV samples, the researchers showed that the magnetostatic edge coupling dominates the switching behavior. In contrast, for thin-film samples, it is governed by a competition between the RKKY and Néel coupling, which can be controlled by the appropriate choice of gap material and thickness on the nanoscale.

More information: Han, G. C. et al. Interlayer couplings in a differential dual spin valve. *Applied Physics Letters* 98, 192502 (2011). apl.aip.org/resource/1/applab/v98/i19/p192502_s1

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