Nature Physics **advance online publication**, 9 October 2007
doi:10.1038/nphys779

Research Highlights

Nobel Prize 2007: Fert and Grünberg

Ed Gerstner

The 2007 Nobel Prize for physics has been awarded to Albert Fert and Peter Grünberg for the discovery of giant magnetoresistance.

iPods, laptops and even Google are among the modern icons made possible by the discovery that is recognized by this year's Nobel Prize in Physics. Giant magnetoresistance is the effect by which digital information stored in the tiny magnetic domains of a computer's hard disk is converted to an electrical signal that can be processed by its silicon chips. Without it, the performance, bulk and cost of computer storage would probably have severely hampered the development of many technological innovations that we now take for granted. And it has inspired the birth of an entire field, known as spintronics.

Giant magnetoresistance, discovered independently by Albert Fert[1] and Peter Grünberg[2] in 1988, arises from the fact that electrons travelling through a ferromagnetic conductor will scatter differently depending on the relative orientation of their spin to the magnetization direction of the conductor — with those oriented parallel scattering less often than those oriented antiparallel. This causes electrons injected from a magnetic conductor into a non-magnetic conductor to be preferentially oriented in one direction. If these electrons then encounter a second ferromagnetic layer, they will pass into it freely from the non-magnetic metal, without strong scattering, only if their preferred orientation is parallel to the magnetization of the second layer. Consequently, the resistance of a trilayer stack of two ferromagnetic metal layers either side of a non-magnetic metal layer depends sensitively on the relative magnetization direction of the two ferromagnetic layers.

This phenomenon is the basis of operation of the read heads that are used in modern computer hard disks. These read heads consist of multiple ferromagnetic and non-magnetic metal layers, but with alternating soft and hard ferromagnetic layers. The magnetization of the hard magnetic layers are fixed during manufacture, but that of the soft layers will be affected by the presence of an external magnetic field. So by placing a read head close to the fields generated by the magnetically encoded bits of a hard disk, the orientation of those bits can be determined through the resistance of the multilayer stack.

Although giant magnetoresistance is ultimately about the flow (or otherwise) of electrons, the fact that their spin is used successfully to mediate this flow is the inspiration for the new field of spintronics. Just as electronics encodes, transmits and processes information in the form of electronic charge, spintronics promises a new generation of devices, circuits and systems that does the same with spin. Not only might this enable computers to become faster and more energy efficient, but it might also enable new functionalities to be developed, such as quantum information processing, that are unavailable through the use of charge alone.

REFERENCES

1. Baibich, M. N. *et al*. Giant magnetoresistance of (001)Fe/(001)Cr magnetic superlattices. *Phys. Rev. Lett.* **61,** 2472–2475 (1988).
2. Binasch, G., Grünberg, P., Saurenbach, F. & Zinn W. Enhanced magnetoresistance in layered magnetic structures with antiferromagnetic interlayer exchange. *Phys. Rev. B* **39,** 4828–4830 (1989).