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Spintronics/Spintronique

Foreword

Nanomagnetism and spintronics are two sides of the same coin. On the one hand, nanomagnetism dates back to the mid-1950s with early works from the likes, amongst others, of Néel, Aharoni, Brown. It has encountered, however, a severe boost in the past ten years thanks to the advances in microfabrication and experimental techniques which have allowed physical objects to be manufactured, measured and even manipulated at the nanometer scale.

Indeed, magnetic nano-objects such as thin films, nanoparticles, nanodots, nanowires and magnetic molecules have revealed new effects as, for example, the quantum dynamic properties exhibited by some magnetic molecules. In turn, they have sustained the growth of applications such as the magnetic storage of information.

On the other hand, spintronics is a relatively new field of research, at the interface between data storage and microelectronics. Spintronics exploits the interplay between the spin and the conduction of electrons in magnetic nanostructures. It emerged with the discovery in 1988 of the giant magnetoresistance (GMR) in magnetic multilayers, which has triggered an intense research activity, leading to several interesting new effects such as TMR (tunneling magnetoresistance), spin filtering, and lately, spin transfer and spin injection into semiconductors, ... Albeit still in its infancy, spintronics already has important applications, with GMR and TMR applied to recording heads fuelling the explosive growth of data storage devices and TMR underlying the intense activity on Magnetic Random Access Memories (MRAM).

In this issue of the CR Physique, we have tried to cover the most exciting topics in nanomagnetism and spintronics with articles by world-renowned specialists in the field.

The first two articles deal with modern nanomagnetism. The article of Fruchard and Thiaville describes the new magnetic properties arising at reduced dimensions in magnetic objects. Barbara then focuses on the quantum properties of nano-magnets, as, for example, the quantum tunnelling of the magnetization in magnetic molecules.

The next three articles lay down the fundamentals of spintronics. Schuhl and Lacour review GMR and TMR. Cros et al. discuss the hot topic of the manipulation of the magnetic moment of a ferromagnetic body by spin-polarized electrical currents. George et al. present another emerging field, spintronics with semiconductors.

Finally, the last four papers are focused on the applications side. Cibert et al. review the research on new materials for spintronics. The article of Childress and Fontana describes the application of GMR to the hard disk drive industry. Sousa and Prebjeanu overview the recent advances in MRAM technology. Bsiesy then concludes on emerging potential applications using spin injection effects.

Nanomagnetism and spintronics remain in their infancy, pretty much still confined to the laboratory. However, there is a feel that some recent scientific breakthroughs could open new avenues for applications, therein leading to a wider acceptance by the microelectronics industry. For example, the use of spin transfer to generate RF signals is one of the potential new game field for the telecoms industry. Hybrid structures associating semiconductors and magnetic metals, as well as magnetic semiconductors, may allow the complementary use of semiconductor and magnetic material properties.

Extensive research through the joint effort of laboratories and industrial companies will probably lead to some fusion between classical electronics and spintronics. We believe we are only at the dawn of spintronics.

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Albert Fert
Unité Mixte de Physique CNRS/THALES (CNRS-UMR137)
route départementale 128
91767 Palaiseau
France
E-mail address: albert.fert@thalesgroup.com (A. Fert)

Jean-Pierre Nozières
SPINTEC
CEA Grenoble
Bâtiment 1005
17, rue des Martyrs
38042 Grenoble cedex
France
E-mail address: nozieres@drfmc.ceng.cea.fr (J.-P. Nozières)

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