Spin Electronics

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PREFACE

Spin Electronics

Conventional electronics has in the past ignored the spin on the electron, however things began to change in 1988 with the discovery of giant magnetoresistance in metallic thin film stacks which led to the development of a new research area, so called spin-electronics. In the last 10 years, spin-electronics has achieved a number of breakthroughs from the points of view of both basic science and application.

Materials research has led to several major discoveries:

- very large tunnel magnetoresistance effects in tunnel junctions with crystalline barriers due to a new spin-filtering mechanism associated with the spin-dependent symmetry of the electron wave functions
- new magnetic tunnelling barriers leading to spin-dependent tunnelling barrier heights and acting as spin-filters
- magnetic semiconductors with increasingly high ordering temperature.

New phenomena have been predicted and observed:

- the possibility of acting on the magnetization of a magnetic nanostructure with a spin-polarized current. This effect, due to a transfer of angular momentum between the spin polarized conduction electrons and the local magnetization, can be viewed as the reciprocal of giant or tunnel magnetoresistance. It can be used to switch the magnetization of a magnetic nanostructure or to generate steady magnetic excitations in the system.
- the possibility of generating and manipulating spin current without charge current by creating non-equilibrium local accumulation of spin up or spin down electrons.

The range of applications of spin electronics materials and phenomena is expanding:

- the first devices based on giant magnetoresistance were the magnetoresistive read-heads for computer disk drives. These heads, introduced in 1998 with current-in plane spin-valves, have evolved towards low resistance tunnel magnetoresistice heads in 2005. Besides magnetic recording technology, these very sensitive magnetoresistive sensors are finding applications in other areas, in particular in biology.
- magnetic tunnel junctions were introduced as memory elements in new types of non-volatile magnetic memories (MRAM). A first 4Mbit product was launched by Freescale in July 2006. Future generations of memories are being developed by academic groups or companies.
- the combination of magnetic elements with CMOS components opens a whole new paradigm in hybrid electronic components which can change the common conception of the architecture of complex electronic components with a much tighter integration of logic and memory.

- the steady magnetic excitations stimulated by spin-transfer might be used in a variety of microwave components provided the output power can be increased. Intense research and development efforts are being aimed at increasing this power by the synchronization of oscillators.

The articles compiled in this special issue of *Journal of Physics: Condensed Matter* devoted to spin electronics, review these recent developments. All the contributors are greatly acknowledged.

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Guest Editors