Alliance 2: Spintronics and Nanomagnetism

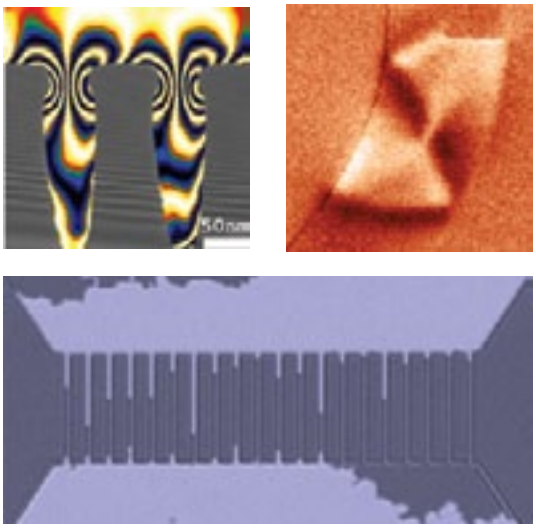
Research axes and facilities

The development of spintronics over the last two decades is based on the discovery of fundamental phenomena linking magnetism with electrical currents, boosted by a strong synergy with applications particularly in magnetic recording, sensors, solid state memories, logic and RF devices and bio-chips. These have also been made possible by the advancement of nanomagnetism, which is the understanding and control of magnetic materials at the nanoscale.

Our activity covers the full spectrum of expertise required for successful fundamental research and its flow towards applications: materials science and nanofabrication; advanced instrumentation with an emphasis on magnetic microscopies and time-resolved measurements; theory and numerical modeling; circuit design and testing. Our work is strengthened by a network of international collaborations, and tight links with neighboring LETI and industrial partners.

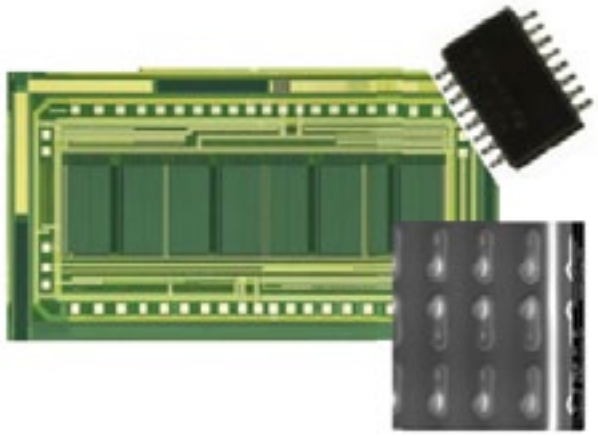
Actions within LANEF

Fundamental investigations. Spintronics is a major focus of the Alliance. Of particular interest is spin transfer, which can be viewed as the reverse effect of Giant Magneto-Resistance (discovered in 1987 by A. Fert in France and P. Grünberg in Germany, awarded the Nobel prize in 2007): conduction electrons get polarized upon traveling through magnetic materials, in turn affecting magnetization thanks to transfer of angular momentum or exchange coupling. We are working actively on exciting or reversing magnetization with an electrical current or voltage, Rashba effects, creation of pure spin currents, novel materials such as magnetic semiconductors. These new frontiers in condensed matter physics are made possible by mastering material science and in particular artificial stackings, embedding together metals, oxides, semiconductors, graphene, etc... To achieve this understanding of magnetic properties at the nanoscale is crucial, such as magnetization arrangement in domains and domain walls, coupling across interfaces, dynamics and thermal effects in low dimensions etc. We address these thanks to the combination of the synthesis of model systems, their investigation with advanced characterization techniques with high time and space resolution (both in-lab and at synchrotrons), and custom theory and numerical codes.



Examples of high-resolution magnetic microscopy

Towards applications. Spintronics allows for a tighter entanglement of magnetism with electronics, with a positive impact on power consumption and miniaturization of devices, as well as new paradigms. A major mission of the Alliance is to transform fundamental knowledge into working principles, in connection with R&D and industrial partners. In Information and Communication Technology the main applications targeted are non-volatile Magnetic Random Access Memory, reprogrammable non-volatile CMOS/magnetic logic, agile RF oscillators for telecommunications. Based on our core expertise we also contribute to developing applications in collaboration with other alliances, such as integrated micro-magnets for biology (e.g. cell manipulation) or magnetic phase change materials for energy harvesting.



Magnetic Random-Access Memory (MRAM)

Education. Many among our staff contribute to lectures and practicals at Grenoble University, with close connection with research. Besides, beyond training PhD students, the alliance contributes to higher education through its key action in several European Schools. In particular, LANEF scientists organise the long-running European School on Magnetism, and have recently set up a similar School dedicated to the training of microelectronics students and engineers on hybrid CMOS/magnetic technology.

Key figures: **45 Permanent scientists, 45 PhD students & postdocs, from INAC and NEEL**

Strong collaborations with ESRF & Soleil (Fra) and Elettra (Ita) synchrotrons; Barcelona & Madrid (Spa) / Dresden, Halle & Hamburg (Ger) / Rio (Bra) / Paris, Lyon & Nancy (Fra)

R&D and industry: Crocus Technology, LETI, Menta, ST-Microelectronics, Thales & Serma (Fra) / Tower semiconductors (USA) / Singulus AG (Ger).

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