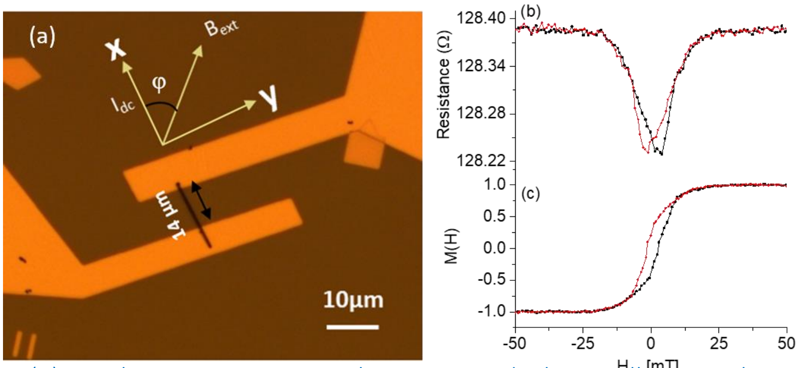
Curvilinear magnetism and spintronics in core-shell nanotubes

Context

The physics of nanomagnetism and spintronics has been mainly developed based on planar structures, making use of thin-film deposition and clean-room patterning technology. This concerns interfacial magnetic anisotropy, magnetoresistance effects, spin-transfer torques, magnonics etc. **3D nanomagnetism and spintronics emerged recently as a new research direction**. A number of fundamentally-new effects are expected, related to 3D spin degrees of freedom, closed boundary conditions in cylindrical nanostructures, and more generally curvature-induced effects. This a fast-developing topic, bringing together experts in chemical synthesis, nanofabrication, imaging and simulation, all developing ever-flexible tools.

This field is the background of the Spin Textures research team of SPINTEC. We have recently developed several key systems, consisting of core-shell magnetic nanotubes and nanowires. These are of crucial interest to translate spintronics in a 3D geometry, as spintronic effects are provided by interfaces. Besides, cores and shells with different functions can be brought together. Here, we propose to make use of such core-shell systems to investigate the physics of domain-wall motion and magnonics, *i.e.*, spin wave propagation, in curved systems. In both cases, we will seek to evidence signatures of the impact of curvature on magnetism, predicted however so far not reported experimentally.



(a) Single magnetic nanotube contacted electrically using laser lithography. Magnetization probed by (b) anisotropic magnetoresistance, converted to (c) a hysteresis loop, revealing the unexpected azimuthal direction of magnetization.

Work program & Skills acquired during internship

The chemical synthesis, combining several cutting-edge techniques, is conducted by several international collaborators. The candidate will be in charge of handling core-shell nanotubes and nanowires, contact them electrically, characterize them in dc and ac electrical measurements, and use a combination of several magnetic microscopies to investigate domain-wall motion under nanosecond pulses of electric current, and the controlled excitation of spin waves. This may involve both in-lab measurements and stays at synchrotron-radiation facilities. The work is conducted jointly with colleagues from the theory group, providing a quick and effective support. Besides direct monitoring, the candidate benefits from weekly meetings in a collaborative environment including experts in electric measurements, advanced magnetic microscopy, and numerical/analytical micromagnetism.

The candidate will learn nanofabrication techniques, electrical measurements and magnetic imaging, as well as a deep physical understanding of nanomagnetism and spintronics, providing a solid and broad basis to start a scientific research career, which we aim to be extended with a PhD project.

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Requested background: Master 2
Duration: 6 months
Start period: Feb/ March 2023
Possibility of PhD thesis : YES
Proposal number : do not fill in