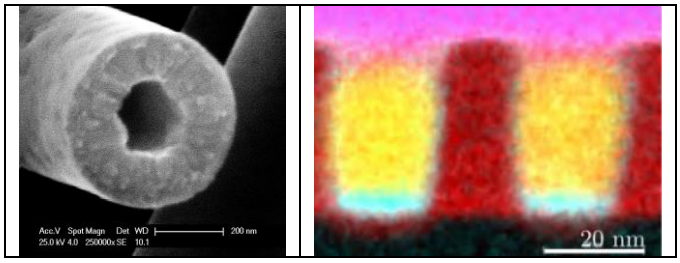
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Atomic Layer Deposition of Pd to seed electroless-grown high-quality ultrathin ferromagnetic layers for 3D spintronics

Context

The fields of nanomagnetism and spintronics are opening to 3D structures, giving rise to new fundamental effects and also creating opportunities for deep integration, compared with standard planar designs. New physical effects arise in magnetic anisotropy, magnetoresistance, spin-transfer torques, the topology of magnetization textures, magnonics etc… On the applied side, opportunities include the translation of logic and storage spintronic circuits to 3D designs, providing higher areal density, better thermal stability or enhanced neuromorphic capacities.



Example of 3D nanomagnetic and spintronic systems investigated at SPINTEC: (left) Core-shell Cu\CoNiB nanotube for the fundamental investigation of domain-wall motion in a tubular geometry (right) Exploratory 3D ferromagnetic storage layers embedded in a SiO2 matrix on Si

One of the challenges arising to translate spintronics from 2D to 3D is the ability to synthesis spintronic stacks on structures with variable shape and curvature, with a structural and electric quality similar to that of planar stacks. The standard physical vapor deposition techniques are not suitable, as they tend to clog narrow openings and induce shading effects. Instead, one requires conformal deposition techniques, which consists of chemical approaches such as Atomic Layer Deposition and Electroless deposition. In general, the former is more suited for oxides, nitrides and some noble and refractory metals, while the latter is more suited for 3d ferromagnetic materials. Electroless deposition is often initiated on nanometer-sized Pd catalyst seeds, which is not suitable to produce ultrathin and low-roughness films. The objective of this internship is to explore the use of atomic-layer-deposited Pd as a seed to produce high-quality ultrathin electroless CoNi ferromagnetic layers.

Work program & Skills acquired during internship

First, the literature of Pd ALD and its use to serve as seed layer (e.g., the case of Cu is well documented) will be reviewed to outline the most promising strategy in terms of precursors, deposition conditions and thickness. Second, ALD Pd films followed by electroless CoNi films will be fabricated, and characterized structurally and magnetically. We intend to first develop know-how on flat surfaces for the ease of analysis, then turn to 3D systems, such as tubular structures or embedded storage electrodes. The work is conducted jointly with colleagues from the spin textures team at SPINTEC, the functional thin films team at LMGP, and the Micro- and Nanomagnetism team at Institut Néel. Besides direct monitoring, the candidate will benefit from weekly meetings in a collaborative environment including experts in physico-chemistry, magnetic materials and electrical measurements.

The candidate will operate ALD and electroless deposition tools, and proceed to the structural and magnetic characterization of the stacks produced. The internship can be extended into a broader to fabricate and investigate novel nanomagnetic and spintronic 3D devices.

https://www.spintec.fr/research/spin-textures

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Requested background: Master 2
Duration: 4-6 months, flexible
Start period: Feb/March 2025, flexible
Possibility of PhD thesis : YES