Laboratoire de Physique & Chimie des Nano-Objets

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Submillimeter magnets for portable magnetic devices

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Location	INSA 135 avenue de Rangueil, 31077, Toulouse

This research master's degree research project could be followed by a PhD. YES **X** NO □

Abstract/work package/short bibliography/illustration

The fabrication and integration of sub-millimeter magnetic materials into predefined circuits is of major importance for POrtable MAgnetic DEvices such as biomedical implants and wireless sensor networks (IoT devices). However, it is still not achieved despite intensive efforts. The main limitation arises from a lack of mature permanent magnet technology for micro-electro-mechanical systems (MEMS).[1] ***There is therefore a need for a compatible process to prepare integrated magnets in the submillimetric range for new developments in microelectronics.***
The POMADE project, recently funded by the French National Agency for Research (ANR), aims at developing **new nanostructured magnets (i) at the submillimeter scale, (ii) locally deposited** and **(iii) integrated into functional devices.** We have recently developed a unique approach at LPCNO to fabricate efficient permanent magnets (PMs) by the controlled assembly of cobalt nanorods[2,3] using magnetophoresis and capillary forces (Figure 1).[4]

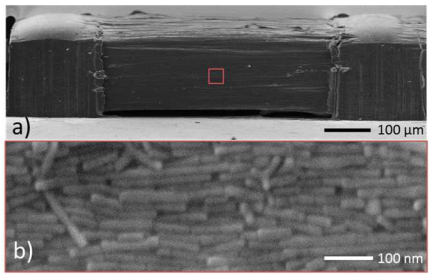

Figure 1. *Scanning Electron Microscopy images of a) a permanent magnet prepared by the controlled alignment of Co nanorods between two Ni blocks electrodeposited. b) High magnification image corresponding to the red square in a) showing the parallel alignment of the Co nanorods within the magnet.*

The nanostructuration of PMs using MEMS compatible processes raises fabrication, characterization and integration challenges that will be tackled within 3 closely linked work-packages:

- The fabrication of thick submillimeter magnets using Co NRs and NdFeB films,
- The advanced structural and magnetic studies of the PM with high spatial resolution,
- The full integration into a MEMS process flow : realization of efficient energy harvesters.

The project, and thus the master thesis subject is multidisciplinary, combining advanced studies in physical and chemical synthesis, physico-chemical post-synthesis assembly, nanomagnetism and MEMS architecture.

The master thesis will more specifically work on fine characterization of the sub-millimeter magnets, both experimentally and theoretically and their further integration into an electromagnetic vibration energy harvester device in close collaboration with the LAAS. He/she will perform advanced magneto-optic and induction mapping at Institut Néel (Grenoble), in the framework of a collaboration. This master thesis will be pursued by a 3 year PhD starting the 1st October 2020, funded by the National Agency for Research (ANR).

1. S. Roy, D. Mallick, K. Paul "MEMS-Based Vibrational Energy Harvesting and Conversion Employing Micro-/Nano-Magnetics". ***IEEE Trans. Magn.*** *55*, 1. (2019)
2. E. Anagnostopoulou et al. "Dense arrays of cobalt nanorods as rare-earth free permanent magnets" ***Nanoscale.*** *8*, 4020 (2016)
3. Consolidation of cobalt nanorods: a new route for rare-earth free nanostructured permanent magnets" S. Ener et al., ***Acta Materiala***, *145*, 290 (2018)
4. L.-M. Lacroix et al. French patent «Procédé de fabrication d'un aimant permanent » (FR1872920)

Keywords, areas of expertise (max 30 words)	Permanent magnets, Comsol Multiphysics simulation, Advanced characterization by X-Ray Diffraction, Electron Microscopy, Magnetometry
Required skills for the internship (max 30 keywords)	The candidate should have a strong physics background and should be willing to work at the chemistry/physics interface. Experiences in magnetism (theory and/or experiments) would be appreciated.

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