NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Combinatorial studies of hard magnetic materials

General Scope:
The demand for high performance rare earth transition metal (RE-TM) hard magnets (Nd-Fe-B, Sm-Co) is continuously growing, in particular for use in power transformation (windmills, (hybrid)-electric-vehicles, electric bicycles) and robotics. The elements at the origin of magnetocrystalline anisotropy and thus coercivity in today's best magnets (Nd, Pr, Dy, Tb, Sm) are from the family of strategically important rare earth elements. To address the growing demand for magnets but the limited supply of REs, much effort is now going into developing magnets in which the most critical REs are partially substituted by under-used and thus much cheaper REs (e.g. Ce, La). Partial substitution of the main transition metal (e.g. Fe in $Nd_2Fe_{14}B$ and Co in $SmCo_5$ based magnets) is also being studied. The thin film combinatorial approach is ideally adapted to study the tuning of both intrinsic and extrinsic magnetic properties in model samples, and can guide the subsequent development of bulk magnets. Beyond optimising known hard magnetic phases, it can also be used to explore for new phases. The experimental data sets can serve as input in the emerging field of machine-learning-led magnet development.

Research topic and facilities available:
This internship concerns the high throughput fabrication and characterization of thin film libraries of hard magnetic materials. Compositionally graded RE-TM based films will be fabricated by sputtering. The influence of composition and post-deposition annealing on both structural and magnetic properties will be explored using high throughput scanning characterization techniques. Composition will be characterized by Energy Dispersive X-Ray analysis in a scanning electron microscope, crystal structure by X-Ray Diffraction and magnetic properties will be probed using an in-house developed scanning polar Magneto-Optic Kerr effect system. Particular emphasis will be placed on the development of automated analysis of XRD data sets.

Possible collaboration and networking:
This internship will be carried out in the framework of a collaboration with the group of Prof. Thomas Schrefl at the Christian Doppler Laboratory for magnet design by machine learning (Danube University Krems, Austria).

Possible extension as a PhD: Yes

Required skills: Materials science / condensed matter physics, coding (python) for data analysis.

Starting date : Spring 2022

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