femto-st SCIENCES & TECHNOLOGIES

PHD subject proposal

SUBJECT:

Study of composite with very high loaded MagnetoCaloric powders for magnetic refrigeration

SUPERVISORS:

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Context:

Magnetic refrigeration is a new research domain appeared twenty years ago that requires multidisciplinary knowledge in physics (e.g. magnetism, thermodynamics, fluid mechanics, heat transfers), materials and forming processes [1-3]. With a 1st order phase transition (i.e. a phase transformation at solid state) near room temperature and a large entropy change up to 30 J/Kg K, NiCoMnIn Heusler alloys are very good candidates for this application [4]. The disadvantage of these intermetallic alloys is their brittleness which does not allow, a priori, to realize watertight regenerators having a good mechanical strength. The COMPOMAG project proposes a technological solution in focusing on the manufacturing of thermoplastic highly loaded in ***MagnetoCaloric (MC)*** powder in order to obtain efficient MC composite regenerators with specific microstructure on its surface (see for instance [5] developped by FEMTO for LaFeSi alloys). This structuring at the microscopic level (i.e. geometrical details at the surface) facilitates stacking of the MC regenerator and simultaneously improves heat transfer and mixing in the fluid boundary layer.

Work program:

The aim of this PHD is, firstly, to elaborate the MC powder by mechanosynthesis and the composite by mixing the powder with a thermoplastic polymer and, secondly, to characterize them in order to identify the effects of elaboration process and the parameters of the constitutive laws. Finally, numerical simulations of the magnetocaloric effect and the elastocaloric one will be performed on simple geometries in order to qualify the efficiency of each of these two cooling strategies. All this should be done in contact with other colleagues from the COMPOMAG project: 2 others PhD students, 2 industrial companies, 3 different departments at FEMTO and 2 colleagues at the Néel Institute at Grenoble.

Profile of the candidate:

We seek candidates with a good theoretical background in continuum mechanics and/or materials science and skills in programming (with Matlab and/or COMSOL) and in one of these fields: magnetism, thermophysical characterizations, material forming process. At least basic knowledge of French would be better for life outside the lab, while English or French can be used to work in the lab.

Description of the lab:

FEMTO-ST (www.femto-st.fr) is a French public research institute with more than 750 collaborators located in a mid-size town (Besançon) itself located near the Swiss and German borders. Besançon is a town with people from many different countries thanks to the University and the “Centre de Linguistique Appliquée” (CLA). This thesis is the result of a collaboration between members of the Applied Mechanics department (DMA), Micro-Nano Science and Systems department (MN2S) and the Energy department (Energy) subsidized by the Bourgogne / Franche-Comté University (ISITE-UBFC project, N° ANR-15-IDEX-03).

References:

[1] O. Tegus, E. Brück, K. H. J. Buschow, et F. R. de Boer, *Nature*, vol. 415, nº 6868, p. 150, janv. 2002.

[2] C. Zimm *et al.*, in *Advances in Cryogenic Engineering*, P. Kittel, Éd. Boston, MA: Springer US, 1998, p. 1759-1766.

[3] K. A. Gschneidner Jr., V. K. Pecharsky, A. O. Pecharsky, et C. B. Zimm, *Materials Science Forum*, 1999.

[4] D. Bourgault *et al.*, *Applied Physics Letters*, vol. 96, nº 13, p. 132501-132501-3, mars 2010.

[5] J. Lanzarini *et al.*, *Materials & Design*, vol. 87, p. 1022-1029, déc. 2015.