Minicolloque n° CPR 25 ☒ **Oral** ☐ **Poster**

Tunable magnetic anisotropy in nanostructured rare earth free magnet obtained by field assisted bottom-up strategy

M. A. Bousnina[1], S. Mercone[1], Huyen Thi Thanh NONG[1,2], N. Jouini[1], F. Schoenstein 1 [a*]

1. Laboratoire des Sciences des Procédes et des Matériaux, Université Sorbonne Paris Nord, CNRS UPR-3407, 99, Av. J. B. Clément, 93430 Villetaneuse, France
2. Institute Jean Lamour, UMR 7198 CNRS - Lorraine University Campus Artem, 2 allée André Guinier, 54011 Nancy

* email : frederic.schoenstein@univ-paris13.fr

Nowadays Nd-Fe-B [1] and Sm-Co [2] systems are the most used materials in the field of permanent magnetism and magnetic recording. However, because of the toxicity of the rare earth extraction and their high price, a major effort is being made in terms of research to develop new materials as an alternative. In this context, several works in the recent years have shown that the anisotropic nanoparticles have proven their interest. Indeed these particles show high remanence and high coercivity. Such characteristics are mainly governed by three parameters (i) the ratio aspect defined by the ratio L/D, (ii) the mono-domain character of the nanoparticle and (iii) the good crystallinity and thus the absence of defects [3]. We have also recently demonstrated by micromagnetic simulation [4-5] and static magnetic measurements [6] that a judicious well-organized dispersed assembly of these anisotropic nanoparticles can bring to tunable magnetic energies suitable for applications. In this purpose, we succeed in developing a novel bottom-up strategy [7] in order to obtain an anisotropic organized nanostructured bulk system enhancing the magnetic behavior of the nano-magnets ensemble. This novel method combines forced hydrolysis in polyol-medium synthesis of rare earth free nanowires [8], and magnetic field assisted Spark Plasma Sintering (SPS) to ensure their consolidation [7]. The first step allows the production of nano-magnet with optimized magnetic properties and it takes benefit from the properties of polyol which act as solvent, complexing and reducing agents to produce a great variety of inorganic materials (oxides, metals, layered hydroxyl salts). The external applied field likely controls the nucleation and growth processes. The second step allows the sintering of massive material with an organized nanostructure resulting from the alignment of the nanowires along the applied magnetic field. This non-conventional compaction technique minimizes the grain growth inside the solid sintered material showing a high relative density (close to 100%). Thus the nanostructured bulk material likely preserves the optimized magnetic performances of the rare earth free nano-magnets as well as presenting the good mechanical properties of the bulk system. We will present our recent studies showing that a macroscopic magnetic anisotropy of the remanent magnetization as well as a good magnetic energy is supported by high mechanical robustness in our nanostructured bulk materials. We will analyze the different experimental parameters used for the field assisted-bottom up strategy (pressure, temperature and magnetic field) as well as the magnetic static properties experimented by two different measurements (DC-SQUID and Vectorial-VSM (see Figure 1)). Our results show that the field-assisted bottom up strategy is a valuable way to create an alternative to standard rare earth magnet. Last but not least, this strategy can be applied to a variety of ferromagnetic compounds, which makes the technique highly versatile in terms of applications.

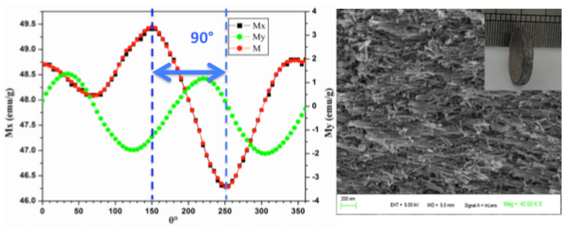

Figure 1: (left hand) Remanent magnetization as function of the in-plane angle of the magnetic field applied. M_x is the component parallel to the field, M_y is the one perpendicular to the field and M is the global magnetization intensity; (right hand) SEM image of the nanostructured magnet.

[1] G. C. Hadjipanayis, J. Magn. Magn. Mater., 1999, 200, 373.
[2] Y. Hou, Z. Xu, S. Peng, C. Rong, J. P. Liu and S. Sun, Adv. Mater.,2007, 19, 3349.
[3] Y. Soumare, J.Y. Piquemal, T. Maurer, F. Ott, G. Chaboussant, A. Falqui, G. Viau ; J. Mater. Chem. (2008) 18, 5696-5702
[4] K. Mrad, F. Schoenstein, H.T.T. Nong, E. Anagnostopoulou, A. Viola, L. Mouton, S. Mercone, C. Ricolleau, N. Jouini, M. Abderraba, L-M. Lacroix, G. Viau, J-Y. Piquemal, CrystEngComm 19 (25), 3476-3484 (2017)
[5] H.T.T. Nong, K. Mrad, F. Schoenstein, JY. Piquemal, N. Jouini, B. Leridon, S. Mercone, Advances in Natural Sciences: Nanoscience and Nanotechnology 8 (2), 025012 (2017)
[6] H. T. T. Nong, T.K. Mai, S. Mercone, Journal of Magnetism and Magnetic Materials 477, 109-117 (2019)
[7] N. Ouar, F.Schoenstein, S.Mercone, S.Farhat, B.Villeroy, B.Leridon, and N. Jouini 2013 *J.Appl. Phys.* 114 163907
[8] Y. Soumare, A. Dakhlaoui-Omrani, F. Schoenstein, S. Mercone, G. Viau, N. Jouini , Solid State Communications 151 (2011) 284–288.