Spinel FeV_2O_4 Vanadates in thin Films

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This phD program aims at taking advantage of the versatility offered by the spinel iron vanadate compounds, combined with the possibilities to closely control the growth of oxides in thin films, to open a path towards new functionalities. Quantum materials FeV_2O_4 (FVO) has been shown to be ferroelectric and multiferroic[1–3]. The richness offered by iron vanadates greatly results from their structure. The V^{3+} cations, located in the octahedral sites of the spinel structure, form a pyrochlore sublattice, and are antiferromagnetically coupled through direct exchange. This results into frustration and yields numerous structural and magnetic phase transitions[4] related to the coexistence of many competing influences (geometric, magnetic, electronic …) within the cell (figure 1). Different mechanisms have been proposed to explain these transitions but the matter is still subject to controversy[5].

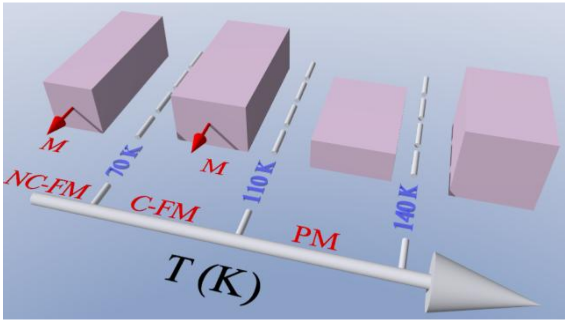

Figure 1 : The température dependant FVO phase transitions, from paramagntic (PM) to non-collinear ferrimagnetic (NC-FM), through collinear ferrimagnetic (C-FM). The red arrows indicate the magnetization (M) direction.

Until now, most of the studies have been performed on bulk materials and the possibilities offered by the growth of thin films in terms of new stresses has not been exploited yet. Studies on FVO thin films are very scarce[6-8], for the control of the valence of the V ions in thin films is not straightforward. The originality is to tune both the structural and magnetoelectronic properties in FVO by using stresses generated by the substrate and/or a cationic substitution. The important stress exerted on structures in thin films, fully tunable through the choice of the substrate and/or a doping element, will be a lever to tune the orbital, charge and spin orderings. Moreover, this stress will tune the V-V distances and a Mott transition is thus expected.

The structural study will be the key point of this study. Resonant crystallography approaches on thin films have already been successfully performed on oxide thin films using the synchrotron beam, even for device samples. Taking into account the objectives, the magnetic order as well as the crystallographic order will be characterized in temperature by resonant diffraction. In parallel, the characterization of thermal and electromagnetic structural transitions will be undertaken (MPMS, AGFM, ...).

[1] Q. Zhang et al., Phys. Rev. B **85**, 054405 (2012).
[2] H. Takei, T. Suzuki, and T. Katsufuji, Appl. Phys. Lett. **91**, 072506 (2007).
[3] A. Kismarahardja et al., Phys. Rev. B **87**, 054432 (2013).
[4] T. Katsufuji et al., J. Phys. Soc. Jpn. **77**, 053708 (2008).
[5] S. Lal and S.K. Pandey, Eur. Phys. J. B **87**, 197 (2014).
[6] D. Zhou et al., Adv. Electron. Mater. 3, 1600295 (2017).
[7] X. Shi, Y. Wang, K. Zhao, X. Lai, and L. Zhang, J. Cryst. Growth 419, 102 (2015).
[8] D. Kim et al., ACS Appl. Electron. Mater. 1, 817 (2019).