Core-shell structure induces new ground states in strontium titanate ceramics

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Hyper-Raman scattering (HRS) is a non-linear spectroscopy sensitive to all polar excitations, in particular the soft modes inactive in Raman. HRS has been applied to nano-ceramics of strontium titanate ($SrTiO_3$) of controlled grain size. Contrary to infrared absorption which sees an average medium, the vibrational responses of the core and the shell(s) are split in HRS, allowing thereby probing the structural and dielectric properties of the two subsystems. The resulting structural model successfully reproduces the effective dielectric permittivity measured by dielectric experiments [1]. These results confirm the strong, but still under-exploited, potentialities of HRS for the investigation of polar materials [2].

We also demonstrate that a new ground state can be obtained by tailoring the core-shell structure of the particles. High energy X-rays at synchrotron combined to neutron diffraction and HRS revealed a lowering of the ferroelastic ground state towards a new antiferrodistortive phase, accompanied with strong shift of the critical temperature [3,4]. This new phase is discussed within the Landau theory, and the crucial competition between particle shape anisotropy, surface tension, and shear strain is analyzed as well. This shows that controlling the core-shell structure provides an easy way to stabilize new phases that cannot exist in bulk material, just like film deposition on a substrate.

[1] M. Al-Sabbagh Ph.D Thesis, to be defended October 21th 2016, Montpellier (article in redaction).
[2] B. Hehlen,M. Al-Sabbagh, A.Al-Zein, and J. Hlinka, Phys. Rev. Lett. 2016 (accepted); A. Al-Zein, J. Hlinka, J. Rouquette, and B. Hehlen, Phys. Rev. Lett. **105**, 017601 (2010).
[3] B.Hehlen, A. Al-Zein, C. Bogicevic, P. Gemeiner, and J.-M. Kiat, Phys. Rev. B **87**, 014303 (2013).
[4] J.-M. Kiat, B. Hehlen *et al*. Phys. Rev. B **93**, 144117 (2016).