High Pressure – High Temperature solid-state reactions: how to play with the chemistry to tune physical properties in multifunctional materials

Chiara Coppi[12*], Francesco Mezzadri[3], Massimo Solzi[2], Riccardo Cabassi[1], Edmondo Gilioli[1], Davide Delmonte[1].
*chiara.coppi@imem.cnr.it

1 Institute of Materials for Electronics and Magnetism, National Research Council (IMEM-CNR), Parco Area delle Scienze 37/A, I-43124, Parma (Italy)
2 Department of Mathematical, Physical and Computer Sciences, University of Parma, Parco Area delle Scienze 7/A, I-43124, Parma (Italy)
3 Department of Chemical Sciences, Life and Environmental Sustainability, University of Parma, Parco Area delle Scienze 17/A, I-43124, Parma (Italy)

High Pressure/High Temperature (HP/HT) solid-state reactions constitute an effective synthesis method to metastabilize novel compounds in the field of fundamental material science. These materials are usually characterized by unusual oxidation states and coordination numbers for cations, which lead to rare crystallographic symmetries. The extreme conditions of HP/HT synthesis force strong structural distortions, which interplay with very exotic physical properties such as the coexistence of magnetism and ferroelectricity in the so called multiferroic materials. Namely, distorted double or quadruple perovskites (AA'BB'O6) can solely be stabilized by HP/HT solid state reaction. Their extraordinary density and tolerance factor allow to explore a wide spectrum of chemical substitutions on both A and B sites. Particularly, through a proper choice of cationic substitutes, it is possible to merge and control multiple and, in some case, complementary functionalities in a single phase.

Here we report a selection of our most interesting materials, successfully synthesized in GPa regime with a Walker-type multianvil press in the last decade, with the aim to show to the community how it is possible to move from monofunctional RT-magnets (as Pb_2FeMoO_6 [1] and Bi_2CuMnO_6), to double-functional proper multiferroics as (Bi_2FeMnO_6 [2-4], YMn_7O_{12} [5,6]) and/or Ferrophotovoltaics, up to triple-functional Multiferroic Ferrophotovoltaics (Bi_2FeCrO_6 [7] and $BaFe_2O_4$ [8]), by finely tuning the composition at the A and B sites of the perovskite.

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