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Metal hydride magnetocaloric compounds

Classical refrigeration technology is using refrigerants (CFC, HCFC, and HFC) which deplete the ozone layer and contribute to global warming, and are or will be forbidden by different climate protocols. The alternative refrigerants (HFO, NH_3, H_2O …) present also various drawbacks. Therefore, it is important to develop new refrigeration technologies without environmental problems such as magnetic refrigeration based on the magnetocaloric effect (MCE). Development of efficient magnetocaloric materials (MCM) for magnetic refrigeration near room temperature has become challenging since the discovery of a giant MCE in $Gd(Ge,Si)_5$ compounds. Intensive studies have yielded the development of several families of materials, among which the $La(Fe,Si)_{13}$ type compounds which display a giant MCE, are not too expensive and are environmental friendly. We have developed a rapid method of synthesis and shaping magnetocaloric $La(Fe,Si)_{13}$ compounds by combining high energy ball milling (BM) with reactive Spark Plasma Sintering (SPS) (Figure 1), a method which is already used to sinter and shape materials at an industrial scale. However, the Curie temperatures of these intermetallics, which is near 200 K, has to be increased near room temperature by Co for Fe substitution or light element insertion like hydrogen. The influence of combining both Fe for Co substitution and hydrogenation to increase T_C above RT and extend the application of these materials to domestic heat pump and low-grade heat recuperation will be presented. We are also searching new MCM families. The $Y_{1-x}R_xFe_2(H,D)_{4.2}$ compounds (R=Gd, Tb) show a ferro(ferri)-antiferromagnetic transition which display a giant isotope effect and MCE. This transition is highly sensitive to any volume changes due to its itinerant electron metamagnetic behavior. The magnetocaloric properties of these compounds will be presented and we will show how the transition temperature can be shifted near room temperature by appropriate chemical substitutions.

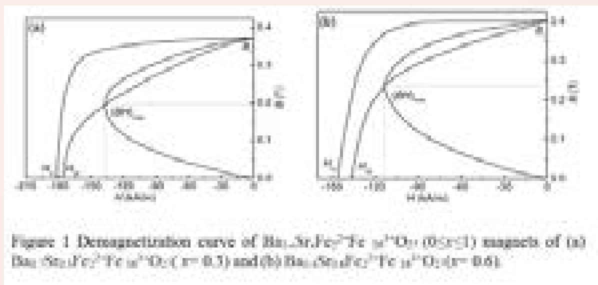

Figure 1: Influence of the temperature on the piston displacement and the XRD patterns of sample pressurized in SPS device. Inset: The magnetic entropy variation at 1273 K

Biography

Valérie Paul-Boncour has developed her expertise in the structural and physical properties of metal-hydrides systems since 1983. Hydrogen absorption in metal and intermetallic induces large structural changes (Cell volume increase, distortion, superstructure, amorphization) and significant modifications of the electronic and magnetic properties. She has developed an expertise in the hydrides of RM_n compounds (R= Rare Earth, M=Mn, Fe, Co, Ni) which display a large variety of original structural and magnetic properties. She has also used the ability of tuning the magnetic properties by hydrogen absorption to synthetize magnetocaloric materials for magnetic refrigeration or heat pumps. She belongs to the Institute of Chemistry and Materials Paris East (ICMPE) created in 2007, which develops multidisciplinary research activities around four main areas: materials for energy, nano-materials and scale effects, materials for the environment and sustainable development, and chemistry at the interface with health and living.

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