Motivation

In the past few years, at IFIMUP-IN (Porto) we have been focusing our efforts into the understanding of the physical mechanisms that rule the magnetocaloric effect on the R$_5$(Si,Ge)$_4$ compounds. Namely, we have identified some features that contribute in a critical way to the performance of these magnetocaloric materials, such as: the tuning of the magnetic and structural transitions, the quality of the samples, and the correlation of these two effects. Therefore, in order to study these features we have used three different tools: chemical substitution, application of high-magnetic fields and thermal treatments. Particularly, here we present four different studies that can be identified as follows:

1. Understanding the role played by Fe on the tuning of magnetocaloric effect in Tb$_5$Si$_4$Ge$_2$.
2. Tailoring the magnetism of Tb$_5$La$_{1-x}$Si$_4$Ge$_2$ compounds by La substitution.
3. Unveiling the (De)coupling of magnetostructural transition nature in Gd$_5$Si$_4$Ge$_2$.
4. Phase control studies in Gd$_5$Si$_4$Ge$_2$ GMC compound.

Understanding the role played by Fe in the MCE of Tb$_5$Si$_4$Ge$_2$

Chemical substitution [Ge → Fe]: Tb$_5$Si$_4$Ge$_2$ − yFe$_y$ system

Fe is predominantly in the Tb$_5$(Si,Ge)$_2$ phase. This phase is responsible for interfacial strain between 5:4 and 5:3 phases, mimicking the external pressure effect.

Unveiling the (De)coupling of magnetostructural transition

Effect of high magnetic fields in R$_5$Si$_4$Ge$_2$, R = Gd and Tb

Phase control studies in Gd$_5$Si$_4$Ge$_2$ GMC compound

Conclusions

- Chemical substitution of both Rare Earth and Transition Metal elements is a very useful tool in order to tune the spin lattice coupling thus improving the magnetic properties ($T_C$, ΔSm, $T_S$);
- Strain caused by secondary phases promotes coupling between structural and magnetic phase transitions (similarly to the effect of external pressure);
- High Magnetic field magnetization measurements is an efficient technique to deepen the studies on the main mechanisms that rule the magnetostructural phase transition;
- Thermal treatments can significantly improve the MCE of a Gd$_5$Si$_4$Ge$_2$ as-cast sample (up to ~50%).