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Invited Talk

Efficient thermomagnetic energy conversion by optimizing the magneto-elastic transition

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The conversion of low-temperature waste heat (T<80°C) from large-scale facilities into electricity by thermomagnetic energy conversion could effectively lower the total energy consumption of modern-day society and therefore reduce emission of greenhouse gasses [1]. Swiss Blue Energy [2] successfully developed and tested a first principle demonstrator of a thermomagnetic motor utilizing Gd, which converts the temperature-induced magnetization change into rotational energy.

Our goal is to replace Gd by an abundantly available material, which has magnetocaloric properties optimized for thermomagnetic energy conversion. Promising candidates are $(Mn,Fe)_2(P,Si,B)$ compounds [3] typically having tuneable Curie temperatures and large magnetization changes. Fine-tuning the character of the magnetic transition towards the critical point between first- and second-order is crucial to achieve the best compromise of maximizing the efficiency of thermomagnetic energy conversion while keeping a reversible process to ensure longevity of the magnetocaloric material.

The mechanism driving the ferromagnetic magneto-elastic transition and consequently the magnetic entropy change is still not fully understood. In order to explore the driving forces in $(Mn,Fe)_2(P,Si,B)$ defining the character of the magneto-elastic transition, we gradually tuned the magnetic transition from a strong first- towards a second-order character by incrementally substituting P by B (Fig).

During this presentation I will discuss correlations between magnetic, structural and electronic degrees of freedom across the magnetic transition in $(Mn,Fe)_2(P,Si,B)$. Finally I will give a brief outlook about suitable materials for thermomagnetic energy conversion.

[1] D. Vuarnoz et al "Quantitative feasibility study of magnetocaloric energy conversion utilizing industrial waste heat", Applied Energy 100 (2012) 229-237

[2] http://www.sbe-ag.ch

[3] F. Guillou et al "Magnetocaloric effect, cyclability and coefficient of refrigerant performance in the MnFe(P,Si,B) system", Journal of Applied Physics 116 (2014) 063903