Contribution ID: **60** Type: **Invited**

Neutron scattering studies on (Mn,Fe)2(P,Si)-type magnetocaloric materials

Thursday 21 July 2016 09:30 (20 minutes)

Magnetic refrigeration has been considered to be the most promising technology to replace vapor-compression for near room-temperature refrigeration applications. Magnetic refrigeration is based on the magnetocaloric effect (MCE). The MCE is a phenomenon, in which a temperature change is caused by exposure of a magnetic material to a changing magnetic field. The cooling efficiency of magnetic refrigeration systems can reach up to 60% of the theoretical limit, compared to about 45% in the best gas-compression refrigerators [1-2]. Magnetic cooling systems operate with less noises and use water-based coolants instead of ozone depleting or greenhouse gases, which makes it an environmentally friendly technology.

(Mn,Fe)2(P,Si)-type compounds are, to date, the most promising materials for such applications due to the combination of outstanding magnetocaloric properties and low material cost. The giant MCE in (Mn,Fe)2(P,Si) compounds originates from a magneto-elastic transition, i.e., the ferromagnetic-parameter (FM-PM) magnetic transition is strongly coupled to a structure change without a symmetry change [3-4].

Due to the strong magnetoelastic coupling in the (Mn,Fe)2(P,Si) compounds, the phase transition can be tuned by changing the Mn/Fe ratio and P/Si ratio, as well as by doping with light atoms [3-5]. Neutron diffraction is a well-suited tool to reveal the structural origin for the tunability of the phase transition, since it has the capability of distinguishing Mn from Fe and P from Si atoms, as well as detecting light atoms.

Our recent neutron diffraction experiments found that in contrast to the common PM-FM phase transition, an intermediate spin-density-wave (SDW) phase is observed for some compositions. The SDW-FM transition is accompanied by a significant increase in the Fe moment and a slight change in the Mn moment. This experimental finding fosters the strong magnetoelastic coupling and Fe moment instability in the (Mn,Fe)2(P,Si) system.

Additionally, we performed xyz neutron polarization analysis in the PM regime of the (Mn,Fe)2(P,Si) compound. The unambiguous separation of the magnetic scattering cross section from the nuclear and spin-incoherent contributions allows us to characterize the spatial correlations of magnetic spins in the PM state. The combination of neutron polarization analysis and muon-spin relaxation experiments provides us a better understanding of the magnetic correlations in the PM state of (Mn,Fe)2(P,Si) compounds, on both the length- and time-scales.

[1] E. Brück, Journal of Physics D: Applied Physics 38, R381 (2005).

[2] O. Gutfleisch, M. A. Willard, E. Brück, et al, Advanced Materials 23, 821 (2011).

[3] N. H. Dung, Z. Q. Ou, L. Caron, et al, Advanced Energy Materials 1, 1215 (2011).

[4] X. F. Miao, L. Caron, P. Roy, et al, Physical Review B 89, 174429 (2014).

[5] X. F. Miao, L. Caron, Z. Gercsi, et al, Applied Physics Letters 107, 042403 (2015).

Author: Mr MIAO, Xuefei (Delft University of Technology)

Co-authors: Prof. BRÜCK, Ekkes (Fundamental Aspects of Materials and Energy, Faculty of Applied Sciences, Delft University of Technology, Mekelweg 15, 2629 JB, Delft, The Netherlands); Dr CARON, Luana (Max Planck

Institute for Chemical Physics of Solids, Nöthnitzer Straße 40, D-01187 Dresden, Germany); Dr VAN DIJK, Niels (Fundamental Aspects of Materials and Energy, Faculty of Applied Sciences, Delft University of Technology, Mekelweg 15, 2629 JB, Delft, The Netherlands)

Presenter: Mr MIAO, Xuefei (Delft University of Technology)

Session Classification: Session IX: Thermoelectrics & Magnetocalorics (Chair: Karin Schmalzl)

Track Classification: Energy storage & transformation