Disordered ferromagnetic state in the Ce-Gd-Tb-Dy-Ho hexagonal high-entropy alloy

P9-7

J. Lužnik,[1] J. Luzar,[1] S. Vrtnik,[1] P. Koželj,[1] A. Jelen,[1] Z. Jagličić,[2] A. Meden,[3] M. Feuerbacher,[4] J. Dolinšek[1]

[1] *J. Stefan Institute and University of Ljubljana, Faculty of Mathematics and Physics, Jamova 39, SI-1000, Ljubljana, Slovenia*
[2] *Institute of Mathematics, Physics and Mechanics and University of Ljubljana, Faculty of Civil and Geodetic Engineering, Jadranska 19, SI-1000, Ljubljana, Slovenia*
[3] *University of Ljubljana, Faculty of Chemistry and Chemical Technology, Vecna pot 113, SI-1000, Ljubljana, Slovenia*
[4] *Institut für Mikrostrukturforschung, Forschungszentrum Jülich, D-52425, Jülich, Germany*
e-mail: janez.luznik@ijs.si

Rare-earth (RE) based hexagonal high-entropy alloys (HEAs) containing elements from the heavy half of the RE series (from Gd to Lu) are considered as prototypes of an ideal HEA. They are stabilized by the entropy of mixing with completely random distribution of the elements on an almost undistorted hexagonal close-packed (hcp) lattice.

In the Ce-Gd-Tb-Dy-Ho hexagonal HEA (HEA-Ce), a light-RE element Ce is alloyed with four heavy-RE elements. The binary mixing enthalpies of Ce with these elements are all zero, therefore random mixing of the elements and an ideal solid solution is expected. Contrary to the expectations, a two-phase structure forms in the HEA-Ce. It consists of the majority hcp matrix and the rhombohedral precipitates that occupy a significant fraction of the sample's volume. Both phases have very similar composition. The "ideality" of the HEA-Ce solid solution is very likely compromised by the fact that the crystal structure of Ce is different from the structures of other elements.

By performing measurements of the magnetic properties, the specific heat and the electrical resistivity in a magnetic field, we have determined the magnetic state of the HEA-Ce [1]. Long-range-ordered periodic magnetic structures do not form (like they do in the hexagonal HEAs containing heavy-RE elements only). The magnetic structure breaks up into ferromagnetically (FM) polarized spin domains distributed in size that orient randomly in zero field. The magnetically ordered state of the HEA-Ce can be described as a disordered FM state with a 2nd-order thermodynamic FM phase transition at $T_C = 140\,\mathrm{K}$. The introduction of Ce did not yield any of the phenomena that are exceptional for the Ce-containing alloys and compounds (heavy-fermion, unconventional superconductivity, mixed valence).

[1] S. Vrtnik, J. Lužnik, P. Koželj, A. Jelen, J. Luzar, Z. Jagličić, A. Meden, M. Feuerbacher, J. Dolinšek, J. Alloys Compd. **742** (2018) 877.