Structural and magnetic properties of multi-frustrated $La_{0.5}R_{0.5}MgCo_2Ni_2$ (R = Y, Ce, Tb) compounds

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Over the past decades, a lot of efforts have been directed to study different Mg-based compounds for hydrogen storage applications and as negative electrodes in a Ni/MH batteries. In this work, we investigate structural and magnetic properties of complex compounds showing structural disorder over magnetic lattice.

The samples were obtained in two steps. At first, the $La_{0.5}R_{0.5}Co_2Ni_2$ alloy was synthesized by arc-melting. Secondly, the precursors were finely ground in agate mortar. The obtained powder was then mixed with magnesium and sintered. Samples were characterised by X-ray diffraction, scanning electron microscopy with energy dispersive X-ray spectroscopy, vibrating sample magnetometry in the 2-300 K temperature range, and neutron diffraction.

X-ray diffraction showed that in the $La_{0.5}R_{0.5}MgCo_2Ni_2$ system, the pyrochlore lattice built from transition metals (Co/Ni) can be found. The second magnetic lattice is face centered one involving the rare earth magnetic atoms. The long-range magnetic order (LRMO) was observed for Tb-based compound, while for the Ce-based one it was absent, basing on magnetometric and neutron diffraction studies. Two of the investigated samples: $La_{0.5}Y_{0.5}MgCo_2Ni_2$ and $La_{0.5}Ce_{0.5}MgCo_2Ni_2$ show signs of spin glass like state from the 1.5 K up to the 350 K. However, the Y-based specimen shows significantly broader departure between FC (field cooled) and ZFC (zero-field cooled) curves. For the Ce-based sample below roughly 100 K the dispersion between FC and ZFC starts to rise. This behavior resembles blocking of superparamagnetic particles. The $La_{0.5}Tb_{0.5}MgCo_2Ni_2$ sample shows magnetic ordering below 35 K. Above that temperature, the system transforms into the cluster spin glass like other compounds. At the 1.5 K the magnetic structure of Tb sublattice is simple ferromagnetic, while the Ni/Co pyrochlore sublattice exhibits antiferromagnetic behavior. For all investigated specimens even in the vicinity of 350 K no Curie-Weiss behavior was noticed.