Pressure Control of Magnetic Clusters in Strongly Inhomogeneous Ferromagnetic Chalcopyrites

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The room-temperature (RT) ferromagnetism in Mn-doped chalcopyrites is an important aspect in applying such materials in spintronics applications [1]. However, dominance of high Curie-temperatures due to cluster formation or inhomogeneities [2] limited their consideration. Herewith we report how an external perturbation such as applied hydrostatic pressure in $CdGeP_2$:Mn induces a two serial magnetic transitions from ferromagnet to non-magnet at RT, coming from unconventional properties of magnetic created MnP micro-clusters. The experimental measurements of ferromagnetically MnP clusters in strongly inhomogeneous Mn-doped $CdGeP_2$, using systematic high-pressure measurements [3] (magnetic, volume and transport) up to 7GPa were carried out. We correlate the observed cluster changes with *ab initio* density functional theory (DFT) calculations. In particular we study the pressure-volume dependence of single MnP clusters as well as the effect of substitutional Mn in the magnetic and structural properties. As it evident, the pressure control of MnP clusters is attainable for higher Mn doping concentration (x>0.135), which also leads to enhancement of the host structure stability with pressure, observation that is consistent with DFT calculations.

Along with the current-induced magnetic switching, the pressure control on the cluster-containing systems proposes a new direction to be explored in the field of spintronics.

[1]. S. C. Erwin and I. Žutić, *Nature Mater*. **3**, 410 (2004).
[2] L. Kilanski, W. Dobrowolski, E. Dynowska, M. Wójcik, B. J. Kowalski, N. Nedelko, A. Ślawska-Waniewska, D. K. Maude, S. A. Varnavskiy, I. V. Fedorchenko, S.F. Marenkin, *Solid State Commun*. **151**, 870 (2011).
[3] T. R. Arslanov, A. Yu. Mollaev, I. K. Kamilov, R. K. Arslanov, L. Kilanski, V. M. Trukhan, T. Chatterji, S. F. Marenkin and I. V. Fedorchenko, *Appl. Phys. Lett*. **103**, 192403 (2013).