Functional Matter
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Functional Matter Seminar

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Origin and control of ferromagnetism in magnetically doped semiconductors

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The demonstrated and foreseen functionalities of ferromagnetic semiconductors such as (Ga,Mn)As and p-(Cd,Mn)Te [1], have stimulated a considerable effort to develop semiconductor systems in which spontaneous magnetization would persist to above room temperature. Indeed, high temperature ferromagnetic features have been found in a number of semiconductors and oxides doped with various transition metals and rare earth elements or even in materials nominally undoped with magnetic elements. At the same time, it is becoming clear that the adequate characterization of these systems requires the application of advanced space-resolved and element-specific tools. On the theoretical side, it has been appreciated that conceptual difficulties of charge transfer insulators and strongly correlated disordered metals are combined in these materials with intricate aspects of heavily doped semiconductors and semiconductor alloys, such as Anderson-Mott localization, defect formation by self-compensation mechanisms, spinodal decomposition, and the breakdown of the virtual crystal approximation [2].

In this talk, after presenting the p-d Zener model that describes successfully (Ga,Mn)As and related systems, the progress in the understanding of the origin of high apparent Curie temperatures in diluted magnetic semiconductors and oxides will be described [3-7]. It will be shown that doping above the solubility limit allows one to fabricate a variety of magnetic nanocrystals embedded coherently into the semiconductor host. Importantly, shape and dimension, and thus blocking temperature of the magnetic particles, can be controlled by co-doping with shallow dopants and through growth parameters. Appealing functionalities of these multicomponent systems will be presented together with prospects for their applications.

[1] see, e.g., T. Dietl, H. Ohno, F. Matsukura, *IEEE—Trans. Electr. Dev.* **54** (2007) 945.
[2] see, e.g., T. Dietl, *J. Phys. Soc. Jpn.* **77** (2008) 031005, and references therein.
[3] T. Dietl, *Nature Mat.* **5** (2006) 673.
[4] H. Katayama-Yoshida, K. Sato, T. Fukushima, M. Toyoda, H. Kizaki, V. A. Dinh, P. H. Dederichs, *phys. stat. solidi (a)* **204** (2007) 15.
[5] S. Kuroda, N. Nishizawa, K. Takita, M. Mitome, Y. Bando, K. Osuch, and T. Dietl, *Nature Mat.* **6** (2007) 440.
[6] T. Dietl, *J. Appl. Phys.* **103** (2008) 07D111.
[7] A. Bonanni, A. Navarro-Quezada, Tian Li, M. Wegscheider, R.T. Lechner, G. Bauer, Z. Matej, V. Holy, M. Kiecana, M. Sawicki, and T. Dietl, *arXiv:0804.3324.*

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