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Subsurfactant Epitaxy for Ferromagnetic Semiconductors

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In this talk, I will discuss a discovery that is expected to have due impacts in two forefront areas of materials research. First, I will introduce "subsurfactant epitaxy" as a novel kinetic pathway toward the synthesis of non-equilibrium structures and materials [1, 2]. The discovery of subsurfactant growth is of broad fundamental- and paramount practical interest, particularly within the context of doping functional materials. Secondly, we have successfully applied this conceptual advance to alleviate a major bottleneck problem in spintronics, namely how to fabricate dilute magnetic semiconductors with ferromagnetic ordering temperatures that exceed room temperature by a comfortable margin while minimizing the structural disorder and inhomogeneities that are intrinsic to high doping levels. Here, we demonstrate that controlled Mn doping of Ge via subsurfactant epitaxy produces ferromagnetic ordering temperatures well above room temperature at doping levels that are at least 20 times lower than those typically invoked in other fabrication techniques. Detailed comparison between samples grown by conventional MBE [3-5], and samples grown via the subsurfactant procedure [2] indicates the vastly superior structure-property relationship of the latter. Subsurfactant epitaxy thus stands as a new and powerful avenue toward superior dopant control in dilute magnetic semiconductors and potentially other semiconductor applications that require doping levels far above the thermodynamic solubility limit. Work done in collaboration with M. Chisholm, L.C. Feldman, A.P. Li, J.R. Thompson, C. Zeng, and Z.Y. Zhang. Funded by NSF-DMR-0306239. ORNL is managed by UT-Battelle, LLC, for the U.S. DOE under constract No. DE-AC-5-00OR22725 [1] W. Zhu et al., Phys. Rev. Lett. 93, 126102 (2004). [2] C. Zeng et al., submitted [3] A.P. Li et al, Appl. Phys. Lett. 86, 152507 (2005) [4] A.P. Li et al., Phys. Rev. B 72, 195205 (2005) [5] Y.D. Park et al., Science 295, 651 (2002)