Epitaxial Ferromagnet on Ge(111)

Changgan Zeng,[1] J.R. Thompson,[1,2] L.C. Feldman,[3,2] S.C. Erwin,[4] and H. H. Weitering[1,2]

[1]*Department of Physics and Astronomy, The University of Tennessee, Knoxville, TN 37996*
[2]*Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831*
[3]*Department of Physics, Vanderbilt University, Nashville, TN 37235*
[4]*Center for Computational Materials Science, Naval Research Laboratory, Washington DC 20375*
E-mail: czeng@utk.edu, jrt@utk.edu, leonard.c.feldman@vanderbilt.edu, erwin@dave.nrl.navy.mil, and hanno@utk.edu

The difficulty of injecting spin-polarized electrons into a semiconductor is a major bottleneck in spintronics research. There are two ways to realize spin injection. One of these is to fabricate a ferromagnetic- metal/semiconductor heterostructure; the other is to use a dilute magnetic semiconductor (DMS) as the spin aligner. The former method does not work well, mainly because of the large conductivity mismatch between the ferromagnetic metal and semiconductor. The latter method is limited by the low Curie temperature, T_c of DMS. We have developed a novel interface with good potential for spin injection, namely an epitaxial ferromagnetic Mn_5Ge_3 film on Ge(111). The Mn_5Ge_3 films are fabricated by depositing Mn and subsequent annealing, or by codeposition of Mn and Ge. Mn_5Ge_3(100)//Ge(111) epitaxy relationship is verified by X-ray diffraction results, due to the small lattice mismatch. STM images display (3_ 3)*R*30° honeycomb structure, which perfectly agrees with the theoretical image of the Mn terminated Mn_5Ge_3 (100) surface. Rutherford backscattering and ion-channeling experiments confirmed the stoichiometry and epitaxy of the film. Magnetic measurements reveal a T_c of about 295 K. The easy axis is in-plane, which is most likely due to the shape anisotropy. The multiplet splitting of the Mn 3*s* core level in x-ray photoemission spectroscopy indicates an average magnetic moment of 2.6μ_B per Mn atom, which is in almost perfect agreement with the spin-resolved band structure calculations and SQUID measurements. This research was sponsored by the Laboratory Directed Research and Development Program of Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.