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Spin-dependent Transport in GaAs/MnAs Core/shell Nanowires

J. LIANG, J. WANG, N.S. DELLAS, B.J. COOLEY, S.E. MOHNEY, R. ENGEL-HERBERT, M.H.W. CHAN, N. SAMARTH, Center for Nanoscale Science and Materials Research Institute, Penn State University, University Park PA 16802. — The integration of a metallic ferromagnet (FM) with a semiconductor (S) in axially- and radially modulated nanowires (NWs) has the potential to open up new opportunities in nanospintronics. We describe a comprehensive study of the structure, magnetism and electrical transport in hybrid core/shell S(GaAs)/FM(MnAs) NWs synthesized by molecular beam epitaxy. This is an unusual system where the competition between magnetocrystalline and shape anisotropies in the FM shell creates a magnetic ordering regime which is distinct from conventional FM metal NWs. We report four probe measurements of the temperature dependence of conductivity and the magnetoresistance (MR) in single NWs over a temperature range 0.5 K - 300 K and in magnetic fields ranging up to 80 kOe. Assuming that electrical transport is dominated by the metallic shell, we use the measured anisotropic MR in conjunction with micromagnetic simulations to gain insight into the magnetization reversal process of the FM shell. We also discuss the possible origins of a striking negative linear MR at high field which becomes more pronounced with increasing temperature. Supported by NSF-MRSEC and ONR.

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