Size Distribution and Anisotropy of Self-assembled MnAs Nanoparticles in GaAs

ROBERT DIPIETRO, HANNAH JOHNSON, STEVE BENNETT, TOM NUMMY, LAURA LEWIS, DON HEIMAN, Northeastern University — The size distribution and anisotropy of composite films of MnAs nanoparticles in a GaAs matrix have been determined by thermomagnetic measurement and subsequently confirmed by electron microscopy studies. The composite was fabricated from a homogeneous Ga$_{0.9}$Mn$_{0.1}$As film grown by MBE and annealed at 520-570 °C to produce superparamagnetic particles of diameter 10-50 nm. Magnetization measurements show a peak in the temperature-dependent zero field cooling (ZFC) moment, $m_{ZFC}(T)$, near the system blocking temperature $T_B$. The distribution in $T_B$ was first obtained from $f(T_B) \propto d/dT [T \cdot m_{ZFC}(T)]$, derived assuming that the moment of a particle below its blocking temperature is zero and varies as $1/T$ above the blocking temperature. The distribution in particle diameter $f(D)$ was obtained using the usual relation between blocking temperature and particle volume, $K_{eff}V/k_BT_B=25$, where $K_{eff}$ is the effective MnAs anisotropy constant. A value for the anisotropy constant was obtained by comparing the thermomagnetic $f(D)$ with the size distribution obtained visually from SEM micrographs, where $\langle D \rangle = 12$ nm and width $\Delta D = 7$ nm for a 50-nm-thick film. The visual and thermomagnetic size distribution functions are found to be nearly identical using $K_{eff} = 160,000$ erg/cm$^3$. Work supported by NSF DMR-097007.

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