Discrete Helicoidal Magnetic States in MnSi thin films

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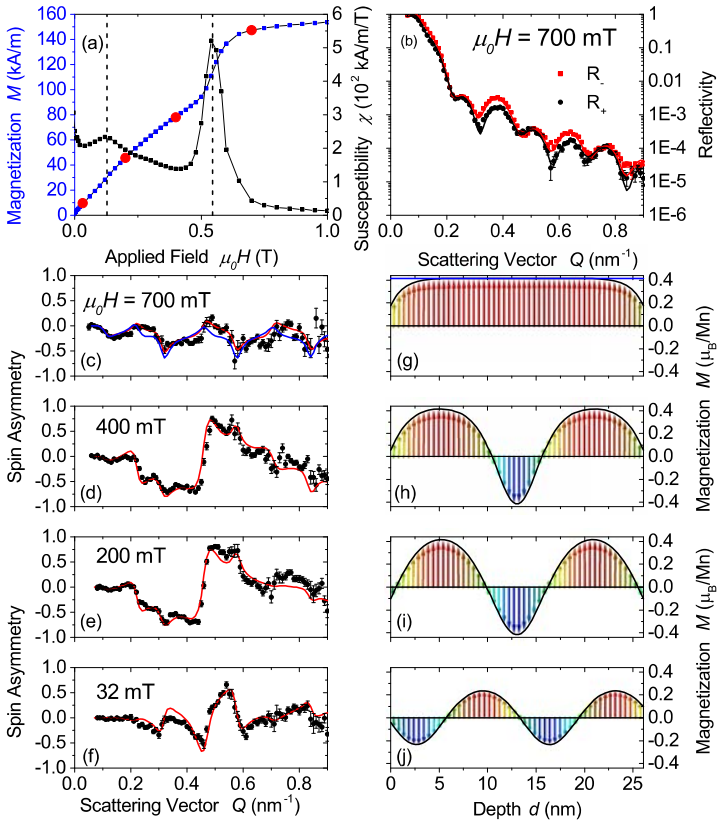
Polarized neutron reflectometry (PNR) and magnetometry measurements in MnSi thin films with analytical solutions of the micromagnetic equations show that the field-induced unwinding in MnSi thin films occurs via discrete steps. PNR measurements were performed on a 26.7 nm thick MnSi film grown by molecular beam epitaxy on on Si(111) substrates. The helical wavelength of the magnetic structure is L_D = 13.9 nm, as determined by pervious PNR measurements [1].

The figure below shows how the magnetic structure evolves discontinuously from a two-turn helical state, to a one-turn helicoid states, and then finally into a twisted-ferromagnetic state. Fig (a) shows the magnetization (blue squares) and magnetic susceptibility (black squares) for the 1.92 L_D sample at a temperature of T = 5 K, plotted with the PNR measurement fields indicated by the red circles, and transition fields shown by dotted lines. Fig (b) show the PNR cross-section for R_- (red squares) and R_+ (black circles) reflectivities for the 1.92 L_D sample measured at T = 5 K, $\mu_0 H$ = 0.7 T. Solid lines show the calculated spin-up (red) and spin-down (black) reflectivity obtained from the solutions to the micromagnetic equations. (c)-(f) Measured (black circles) and calculated (red line) spin asymmetry for the 1.92 L_D sample at T = 5 K, $\mu_0 H$ = 700, 400, 200, and 32 mT. Excellent agreement is achieved without any fitting parameters. (g)-(j) Magnetization depth profiles used to calculate the spin asymmetries shown in figures (c)-(f). The blue line in (c) shows the spin asymmetry calculated for the ferromagnetic state with a depth profile shown by the blue line in (g). More details can be found in Ref. [2].



References

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