

**FERROMAGNETIC THIN FILMS WITH FCC STRUCTURE AS DESCRIBED BY FOURTH ORDER PERTURBED HEISENBERG HAMILTONIAN WITH SEVEN MAGNETIC PARAMETERS**

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Magnetic properties of fcc structured ferromagnetic ultra-thin films with two spin layers were described using fourth-order perturbed Heisenberg Hamiltonian with all seven magnetic energy parameters. Spin exchange interaction, magnetic dipole interaction, second-order and fourth-order magnetic anisotropy constants, in-plane and out-plane, applied magnetic fields, demagnetization factor and stress-induced anisotropy were considered in the model. 3D plots of total magnetic energy versus angle and stress-induced anisotropy were plotted for different values of fourth-order magnetic anisotropy constants. All other magnetic energy parameters were fixed at constant values. All the peaks are closely packed in the graphs plotted using the fourth-order perturbed Heisenberg Hamiltonian compared to peaks in the graphs plotted using the second and third-order perturbed Heisenberg Hamiltonian. The maximum energy varies from  $10^{51}$  to  $10^{49}$  as the fourth-order magnetic anisotropy constants in the bottom ( $D_1^{(4)}$ ) and top ( $D_2^{(4)}$ ) spin layers are changed from  $\frac{D_1^{(4)}}{\omega} = 5$  and  $\frac{D_2^{(4)}}{\omega} = 10$  to  $\frac{D_1^{(4)}}{\omega} = 10$  and  $\frac{D_2^{(4)}}{\omega} = 5$ , respectively. The order of magnetic energy changes when the values of fourth-order anisotropy constants of two spin layers are interchanged. The magnetic energy was higher when the value of the fourth-order anisotropy constant in the bottom spin layer was higher than that of the top spin layer. In addition, the graphs of energy *versus* angle were plotted to find the magnetic easy and hard directions. The angle between the magnetic easy and hard direction was not 90 degrees in all the cases. The orientation of the magnetic easy axis is important in the applications of magnetic recording media.

**Keywords:** Fourth-order perturbed Heisenberg Hamiltonian, Magnetic anisotropy constant, Magnetic thin films, Spin, Stress-induced anisotropy