Home Problem Set #5 자성재료특강 Due : 11. 19 (Wed) , 2008

1. 입방정 결정(cubic crystal)의 자기 이방성 에너지 (magnetic anisotropy energy) E_a는 아래와 같이 나타낼 수 있다.

$$E_a = K_0 + K_1(a_1^2a_2^2 + a_2^2a_3^2 + a_3^2a_1^2) + K_2\,(a_1^2a_2^2a_3^2) + \cdots$$

여기서 a_1, a_2, a_3는 각각 direction cosine들로 각 결정 축(crystal axis)과 and $\boldsymbol{M}_s$ 방향 사이에 이루는 각도의 cosine값들이다.

(a) Fe결정(BCC 구조)의 <100>, <110>, <111> 결정 축 방향들에 대해 E_a를 계산하라. Fe결정의 자기이방성계수는 $K_1 = 0.48\times10^5$ joule/m^3, $K_2 = 0.05\times10^5$ joule/m^3 이다.

(b) 위의 계산 결과를 토대로 볼 때 Fe결정의 easy axis와 hard axis는 각각 어느 방향인가?

2. A magnetic field is applied in the base plane of cobalt. The easy axis direction is the unique axis. Using $K_u = 4.1\times10^5$J/m^3 and $M_s = 1.42\times10^6$ A/m, calculate the field needed to rotate the magnetic moments (a) into the base plane (*i.e.*, perpendicular to the unique axis) and (b) 45°from the hexagonal axis.

3. (a) Find the saturation magnetostriction λ_s of Ni single crystal in the direction <110>, where $\lambda_{100} = -46\times10^{-6}$ and $\lambda_{111} = -24\times10^{-6}$ for the Ni crystal. In cubic crystals, the saturation magnetostriction is given by $\lambda_s = \frac{3}{2}\lambda_{100}(a_1^2\beta_1^2+a_2^2\beta_2^2+a_3^2\beta_3^2 - \frac{1}{3}) + 3\lambda_{111}(a_1a_2\beta_1\beta_2+a_2a_3\beta_2\beta_3 + a_3a_1\beta_3\beta_1)$. Where, are a_1, a_2, a_3 are direction cosines between crystal axes and the magnetization direction (*i.e.*, $\boldsymbol{M}_s$), β_1, β_2, β_3 are direction cosines between measuring direction of λ_s and the crystal axes.

(b) Show the saturation magnetostriction λ_s for a cubic polycrystal is given by $\lambda_s = (2\lambda_{100} + 3\lambda_{111})/5$, assuming completely random domains, and calculate λ_s for Ni polycrystals.