

# Homework #6

① (문제는 정답입니다)

1).

$$a). E_{ms} = \frac{1}{2} M_o N \cdot M_s^2 \left( \frac{d}{L} \right)$$

$$E = E_{ms} + E_{wall} = \frac{1}{2} M_o \cdot N \cdot M_s^2 \left( \frac{D}{L} \right) + \frac{\gamma \cdot L}{D}, \quad \frac{dE}{dD} = 0$$

$$\frac{1}{2} M_o N M_s^2 \left( \frac{1}{L} \right) - \frac{\gamma \cdot L}{D^2} = 0$$

$$\gamma = \frac{M_o \cdot N M_s^2 D^2}{2 L^2} = \frac{4\pi \times 10^{-7} \times 0.5 \times ((1 \times 10^6)^2 \times (5 \times 10^{-6})^2)}{2 \times (1 \times 10^{-2})^2} \approx 7.854 \times 10^{-2} \text{ (J/m²)}$$

$$b). \gamma = 2 \sqrt{\frac{M_o J S^2 \pi^2 K}{a}} \quad \therefore J = \frac{\gamma^2 a}{4 S^2 \pi^2 K M_o} = 1.87 \times 10^{-7} \text{ (J/m²)}$$

$$E_{ex} = -M_o Z J \quad \vec{s}_i \cdot \vec{s}_j = -3.53 \times 10^{-7} \cos \phi \\ = 3.53 \times 10^{-7} \text{ (J)}$$

2)

$$l = \left( \frac{J S^2 \pi^2}{K a} \right)^{1/2} = \left( \frac{3 \times 10^{-21} \cdot \frac{\pi^2}{4}}{40 \times 10^5 \times 10^{-7} \times 10^6 \times 3 \times 10^{-18}} \right)^{1/2} = 7.85 \times 10^{-9} \text{ (cm)}$$

$$\gamma = \sigma_{ex} + \sigma_{an} = \left( \frac{J \cdot S^2 \pi^2}{K u \cdot a^3} \right)^{-1/2} \cdot \frac{1}{a^2} J S^2 \frac{\pi^2}{4} + K u \left( \frac{J S^2 \pi^2}{K u a^3} \right)^{1/2} \cdot a \\ = \frac{J^{1/2} \cdot S \pi K u^{1/2}}{a^{1/2}} + \frac{J^{1/2} \cdot S \pi \cdot K u^{1/2}}{a^{1/2}} = 6.28 \times 10^{-3}$$

$$l_c = \frac{\gamma}{\frac{4}{9} M_o \cdot M_s^2} = \frac{6.28 \times 10^{-3}}{\frac{4}{9} \times 4\pi \times 10^{-7} \times (0.38 \times 10^6)^2} = 7.79 \times 10^{-8} \text{ (m)}$$

3).

$$a) (a = 2.5 \text{ Å}, K = 45 \times 10^5 \text{ ergs/cm}^3)$$

$$\theta = 1131^\circ \text{C} = 1404 \text{ K}$$

$$\sigma_{ex} = \frac{3K\theta}{2ZS(S+1)}, \quad \text{curie temperature.}$$

$$Z = 12, S = \frac{1}{2}$$

$$\sigma_{ex} = \frac{3 \times (1.38 \times 10^{-23}) \times 1404}{2 \times 12 \times \frac{1}{2} \times \frac{3}{2}} = 3.23 \times 10^{-21} \text{ J} (= 3.23 \times 10^{-14} \text{ erg})$$

## [3] 解答.

a) 자석화제

$$\delta = \sqrt{\frac{JS^2\pi^2}{ka}} = \sqrt{\frac{3.23 \times 10^{-14} \times \left(\frac{1}{2}\right)^2 \times \pi^2}{(45 \times 10^5) \times 2.51 \times 10^{-8}}} = 84 \text{ \AA}$$

자역 에너지 밀도  $\gamma = 2k\delta = 2 \times (45 \times 10^5) \times (84 \times 10^{-8}) = 7.56 \text{ (erg/cm}^2\text{)}$

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b)  $k = 33 \times 10^5 \text{ ergs/cm}^3$ ,  $T_c = 450^\circ\text{C}$ ,  $M_s = 380 \text{ emu/cm}^3$

$$\text{자석화제} \quad \delta = \sqrt{\frac{0.3 k T_c \pi^2}{4ka}} = \sqrt{\frac{0.3 \times (1.38 \times 10^{-16}) \times 923 \times \pi^2}{4 \times (33 \times 10^5) \times (3 \times 10^{-8})}} = 8.64 \times 10^{-7} = 86.4 \text{ \AA}$$

2차원 energy 2/2.

$$\gamma = 2k\delta = 2 \times (33 \times 10^5) \times (86.4 \times 10^{-8}) = 5.7 \text{ erg/cm}^2$$

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$$\therefore \gamma_c = \frac{1.7\gamma}{\pi^2 M_s^2} = \frac{1.7 \times 5.7}{\pi^2 \times 380^2} = 6.79 \times 10^{-6} \text{ cm} = 679 \text{ \AA}$$

## [4]

180° domain wall thickness is given by

a) Show that, for a 180° domain wall thickness is given by

$$l_d = \sqrt{\frac{JS^2\pi^2}{ka}}$$

$$E_{ex} = -2JS^2 \cdot \left(1 - \frac{\phi}{2}\right)^2 \quad \left( \begin{array}{l} \sigma_{ex} = \frac{n E_{ex}}{a^2} \\ \sigma_{an} = |K_u N_a| \end{array} \right)$$

$$\therefore \sigma_{tot} = \frac{n}{a^2} \left( JS^2 \left( \frac{\pi}{n} \right)^3 - 2JS^2 \right) + |K_u N_a|$$

$$\therefore n = \left( \frac{JS^2\pi^3}{Ka^3} \right)^{1/2} \quad \therefore l_d = n \cdot a = \left( \frac{JS^2\pi^2}{Ka} \right)^{1/2}$$

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(3)

**[4]**

b)  $J_s^2 = \frac{K_u n^2 a^2}{\pi^2} = \frac{K_u n^2 a^3}{\pi^2} \quad \therefore \Omega_{tot} = \frac{n}{a^2} \left( \frac{K_u n^2 a^3}{\pi^2} \cdot \frac{\pi^2}{n^2} \right)$

$$+ K_u N_a.$$

$$= K_u \cdot n \cdot a + K_u N_a = 2 K_u \cdot l_d.$$

c)  $J = 0.3 k_B T_c$

$$\Omega_{dw} = \frac{E_{ex} N}{a^2} + K_u N_a = \frac{J S^2 \pi^2 N}{N^2} + K_u N_a.$$

$$E_{ex} = -2 J S^2 \cos \phi \rightarrow J S^2 \left( \frac{\pi}{N} \right)^2.$$

$$\therefore \left( \frac{\partial}{\partial N} \Omega_{dw} \right) = 0 = - \frac{J S^2 \pi^2}{N^2 a^2} + K_u \cdot a. \quad \therefore N_o = \left( \frac{J S^2 \pi^2}{K_u a^3} \right)^{1/2}$$

$$\text{wall width} = N_o a = \left( \frac{J S^2 \pi^2}{K_u a^3} \right)^{1/2} = 2.99 \times 10^{-8} \text{ (cm)}.$$

$$\Omega_{dw} = \Omega_{ex} + \Omega_{an} = \frac{J S^2 \pi^2}{N a^2} + K N_a. = 1.437 \times 10^{-3} + 1.435 \times 10^{-3} \\ = 2.874 \text{ (J/m}^2\text{)}.$$

**[5]**

a)  $E = E_{ms} + E_{wall} = 1.7 M_s^2 D + \gamma \frac{L}{D}$

$$\frac{\partial E_{tot}}{\partial D} = 1.7 M_s^2 - \frac{L \gamma}{D^2} = 0 \quad \therefore D^2 = \frac{L \gamma}{1.7 M_s^2} \quad D = \left( \frac{L \gamma}{1.7 M_s^2} \right)^{1/2}$$

$$\therefore E_{tot} = \frac{1.7 M_s^2 D^2 + L \gamma}{D} = \frac{2 L \gamma}{D} = \sqrt{\frac{L \gamma}{1.7 M_s^2}} = 2 \sqrt{1.7 M_s^2 L \gamma}.$$

b) in cobalt,  $\gamma = 7.6 \text{ erg/cm}^2$ ,  $L = 1 \text{ cm}$ ,  $M_s = 1422 \text{ emu/cm}^3$

$$\therefore D = \sqrt{\frac{7.6 \cdot 1}{1.7 \times (1422)^2}} = 1.48 \times 10^{-3} \text{ cm} \quad \therefore \left( \frac{1}{1.48 \times 10^{-3}} \right) \\ = 675.6 \text{ m}.$$

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④

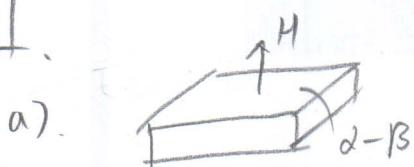
[5] 계산.

$$c) \frac{E_{\text{single}}}{E_{\text{multi}}} = \frac{\frac{2\pi M_s^2 L}{2\sqrt{1.2 M_s^2 r b}}}{\sqrt{\frac{M_s^2 \pi^2 b}{1.7 r}}} = \sqrt{\frac{1422^2 \times \pi^2 \times 1}{1.7 \times 7.6}} \approx 1243$$

→ multi domain의 일정지가  $\frac{1}{1243}$ 인 각으로 single domain ≈ multi domain으로 나누어.

$$d) L_c = \frac{1.7 r}{\pi^2 M_s^2} = \frac{1.7 \times 7.6}{\pi^2 \times 1422^2} \approx 6.47 \times 10^{-7} (\text{cm})$$

[6].



$$\frac{M_o}{2} H M_s = N \times M_o M_s^2 - M_o H M_s + K_u (d_1^2 d_2^2 + d_2^2 d_3^2 + d_3^2 d_1^2)$$

$$\therefore \frac{M_o}{2} H M_s = 1 M_o M_s^2 - M_o H M_s$$

$$= \frac{3}{2} M_o H M_s = M_o M_s^2$$

$$\frac{3}{2} M_o H = M_o H \rightarrow M = \frac{3}{2} H$$

b)



$$\frac{M_o}{2} H M_s = \frac{1}{3} M_o M_s^2 - M_o H M_s \cos \theta + [K_u (d_1^2 d_2^2 + d_2^2 d_3^2 + d_3^2 d_1^2)]$$

$$\therefore \frac{M_o H M_s}{2} = \frac{1}{3} M_o M_s^2 - M_o H M_s + K_u \cdot \frac{1}{3}$$

$$\therefore \frac{3}{2} M_o H M_s = \frac{1}{3} M_o M_s^2 + \frac{K_u}{3}$$