HW 4

Problem 1

(a)

$$f = 2.5G, \epsilon = 40\epsilon_0, \sigma = 2$$
$$K_I = w\sqrt{u\epsilon}[\frac{1}{2}\sqrt{1+\frac{\sigma^2}{\epsilon^2 w^2}} - 1]^{0.5}$$
$$d_p = \frac{1}{K_I} \approx \frac{2}{\sigma}(\frac{\epsilon}{u})^{0.5} = 0.167m$$
$$当\sigma = 4\times 10^{-6}, \epsilon = 1.03\epsilon_0时$$
$$d_p = \frac{1}{K_I} = 1346.97m$$

(b)

$$\frac{w\epsilon}{\sigma} << 1$$
$$由于\frac{w\epsilon}{\sigma} < 0.1$$
$$w < 0.1\frac{\sigma}{\epsilon}$$
$$f = \frac{w}{2\pi} = 898755hz$$

(c)

$$\epsilon = \epsilon_0, u = u_0, \sigma = 3.54\times 10^7$$
$$d_p = \sqrt{\frac{2}{wu\sigma}} = 8.45\times 10^{-6}$$
$$5d_p = 4.23\times 10^{-5} > 10^{-3}(inch)$$
$$不够厚$$

(d)

$$由于\frac{\sigma}{w\epsilon} >> 1$$
$$f = 100Hz时$$
$$d_p = \sqrt{\frac{2}{wu\sigma}} = 25.16m$$
$$f = 5MHz时$$
$$d_p = \sqrt{\frac{2}{wu\sigma}} = 0.1125m$$

(e)

$$d_p = \sqrt{\frac{2}{wu\sigma}} = \frac{1}{K_I}$$
$$e^{-2K_I z} = -109.1dB$$

Problem 2

(a)

$$\epsilon = 40(1+i0.3)\epsilon_0, f = 2.5GHz$$
$$K_I = w\sqrt{u\epsilon}[\frac{1}{2}\sqrt{1+\frac{\sigma^2}{\epsilon^2 w^2}}-1]^{0.5}$$
$$d_p = \frac{1}{K_I} \approx \frac{2}{\sigma}(\frac{\epsilon}{u})^{0.5} = 0.167m$$

(b)

$$f = 60Hz, \sigma = 4, \epsilon = 80\epsilon_0, u = u_0$$
$$K_I = w\sqrt{u\epsilon}[\frac{1}{2}\sqrt{1+\frac{\sigma^2}{\epsilon^2 w^2}}-1]^{0.5}$$
$$\text{由于}\frac{\sigma}{w\epsilon} >> 1$$
$$d_p = \frac{1}{K_I} \approx \sqrt{\frac{2}{wu\sigma}} = 32.487m$$
$$loss\ \ tangent = \frac{\sigma}{wRe(\epsilon) - Im(\epsilon)} = 1.5 \times 10^7$$
$$f = 10MHz\text{时，}d_p = 0.079577m$$
$$loss\ \ tangent = \frac{\sigma}{wRe(\epsilon) - Im(\epsilon)} = 90$$

(c)

$$E_0 = 1V/m$$
$$k = \frac{w}{c}\sqrt{1-\frac{w_p^2}{w^2}}$$
$$E = E_0 e^{ikz}$$
$$z = 100\text{时，}E = 0.019V/m$$
$$< S >= \frac{k}{wu}|E|^2$$
$$z = 0\text{时，}E = 1V/m, < S >= 25W/m^2$$
$$z = 100\text{时，}E = 0.019V/m\text{，}\ \ < S >= 8.39 \times 10^{-3}W/m^2$$

Problem 3

(a)

$$d_p = \sqrt{\frac{m}{Ne^2u_0}}$$

$$proof: d_p = \frac{1}{K_I}$$

$$K_I = \frac{w}{c}\sqrt{\frac{w_p^2}{w^2} - 1}$$

$$w_p = \sqrt{\frac{Nq^2}{m\epsilon_0}}$$

$$=> d_p = \frac{1}{K_I} = \frac{c}{w\sqrt{\frac{Nq^2}{m\epsilon_0 w^2} - 1}}$$

$$d_p = \sqrt{\frac{mc^2\epsilon w^2}{w^2Nq^2 - m\epsilon w^2}} = \sqrt{\frac{m}{\frac{Nq^2}{c^2\epsilon} - \frac{m}{c^2}}} = \sqrt{\frac{m}{Ne^2u_0}}$$

(b)

$$N = 7 \times 10^{28} m^{-3}$$

$$d_p = \sqrt{\frac{m_e}{Ne^2u_0}} = 2.008 \times 10^{-8}$$

(c)

$$\text{对于}good\ conductor\text{，}d_p = \delta = \sqrt{\frac{2}{wu\sigma}}$$

$$\text{对于}superconductor\text{，}d_p = \delta = \sqrt{\frac{m}{Ne^2u_0}}$$

$$\text{当磁场强度变化慢时，}\sqrt{\frac{2}{wu\sigma}}\text{增大；}d_p\text{增加}$$

$$\text{但}\sqrt{\frac{m}{Ne^2u_0}}\text{与频率无关，因此不能穿透}$$