## **HW 4**

## **Problem 1**

(a)

$$f=2.5G, \epsilon=40\epsilon_0, \sigma=2$$
  $K_I=w\sqrt{u\epsilon}[rac{1}{2}\sqrt{1+rac{\sigma^2}{\epsilon^2w^2}}-1]^{0.5}$   $d_p=rac{1}{K_I}pproxrac{2}{\sigma}(rac{\epsilon}{u})^{0.5}=0.167m$   $onumber =\sigma=4 imes10^{-6}, \epsilon=1.03\epsilon_0$ 时  $d_p=rac{1}{K_I}=1346.97m$ 

(b)

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

(c)

$$\epsilon=\epsilon_0, u=u_0, \sigma=3.54 imes10^7$$
 $d_p=\sqrt{rac{2}{wu\sigma}}=8.45 imes10^{-6}$  $5d_p=4.23 imes10^{-5}>10^{-3}(inch)$ 不够厚

(d)

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

(e)

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

## **Problem 2**

(a)

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

(b)

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

(c)

$$E_0=1V/m$$
  $k=rac{w}{c}\sqrt{1-rac{w_p^2}{w^2}}$   $E=E_0e^{ikz}$   $z=100$ 时, $E=0.019V/m$   $< S>=rac{k}{wu}|E|^2$   $z=0$ 时, $E=1V/m, < S>=25W/m^2$   $z=100$ 时, $E=0.019V/m$ , $< S>=8.39 imes10^{-3}W/m^2$ 

## **Problem 3**

(a)

$$d_p = \sqrt{rac{m}{Ne^2u_0}}$$
 $proof: d_p = rac{1}{K_I}$ 
 $K_I = rac{w}{c}\sqrt{rac{w_p^2}{w^2}-1}$ 
 $w_p = \sqrt{rac{Nq^2}{m\epsilon_0}}$ 
 $=> d_p = rac{1}{K_I} = rac{c}{w\sqrt{rac{Nq^2}{m\epsilon_0w^2}-1}}$ 
 $d_p = \sqrt{rac{mc^2\epsilon w^2}{w^2Nq^2-m\epsilon w^2}} = \sqrt{rac{m}{rac{Nq^2}{c^2c}-rac{m}{c^2}}} = \sqrt{rac{m}{Ne^2u_0}}$ 

(b)

$$N = 7 imes 10^{28} m^{-3} \ d_p = \sqrt{rac{m_e}{Ne^2 u_0}} = 2.008 imes 10^{-8}$$

(c)

对于
$$good\ conductor,\ d_p=\delta=\sqrt{rac{2}{wu\sigma}}$$
对于 $superconductor,\ d_p=\delta=\sqrt{rac{m}{Ne^2u_0}}$ 当磁场强度变化慢时, $\sqrt{rac{2}{wu\sigma}}$ 增大; $d_p$ 增加 $\sqrt{rac{m}{Ne^2u_0}}$ 与频率无关,因此不能穿透