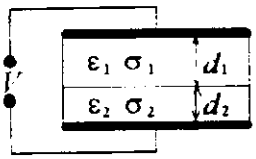
所　別：電子工程技術研究所　　組別：元件與材料組　　科目：電磁學與固態電子學
學程別：

電磁學部分，(1)~(3) 共三題

1. (16%) In the figure at right, a parallel plate capacitor (having perfectly conducting plates) within the plate separation is filled with two layers of material (1) and (2). The first layer has dielectric constant ε_1, conductivity σ_1, and thickness d_1, while the second layer, ε_2, σ_2, and d_2, respectively. A potential V is placed across the capacitor. Neglect edge effects.



(a) What is the electric field in material (1) and (2) ?
(b) What is the current flowing through the capacitor ?
(c) What is the total surface charge density on the interface between (1) and (2) ?
(d) What is the free surface charge density on the interface between (1) and (2) ?

2. (18%) The Lorentz force law for a particle of mass m and charge q is

$$\mathbf{F}=q\left(\mathbf{E}+\frac{\mathbf{v}\times\mathbf{B}}{c}\right)$$

(a) Show that if the particle moves in a time-independent electric field $\mathbf{E} = -\nabla\phi(x,y,z)$ and any magnetic field $\mathbf{B}$, then the energy $\frac{1}{2}mv^2+q\phi$ is a constant.
(b) If the particle moves along x-axis in the electric field $\mathbf{E} = A\exp(t/\tau)\mathbf{e}_x$, where A and τ are both constant, and $\mathbf{e}_x$ is the unit vector in x-direction. If the magnetic field is zero along x-axis and $x(0)=\dot{x}(0)=0$. Find $x(t)$.
(c) In (b), is $\frac{1}{2}mv^2+qxA\exp(t/\tau)$ a constant ? Show your result.

3. (16%) Answer the following questions:
(a) Write down Maxwell's equations in a non-conducting medium with constant permeability and susceptibility. Show that $\mathbf{E}$ and $\mathbf{B}$ each satisfies the wave equation, and find an expression for the wave velocity. Write down the plane wave solutions for $\mathbf{E}$ and $\mathbf{B}$, and show how $\mathbf{E}$ and $\mathbf{B}$ are related.
(b) Discuss the reflection and refraction of electromagnetic waves at a plane interface between the dielectrics and derive the relationships between the angle of incidence, reflection and refraction.

固態電子學部分，(4)~(7) 共四題

4. (10%) Explain why BJTs (bipolar junction transistors) are fabricated from Si (111) wafers, while MOSFETs (metal-oxide-semiconductor field-effect transistors), from Si (100) wafers ?

5. (10%) Why carriers in the base region of a BJT of ordinary size, e.g., 1μm, can be treated as classical particles ? What will happen, if its dimension shrink down to 20Å ? Explain in detail.

6. (15%) If both donor and acceptor atoms are added to the same region in a semiconductor, express the equilibrium electron and hole concentrations in terms of donor concentration *N*d and acceptor concentration *N*a.

7. (15%) If excess electron-hole pairs are created at a particular point in a semiconductor with a pulse of applied electric field, the excess carriers will tend to drift in opposite directions. Establish first the time-dependent total current equations for electrons and holes, respectively, and then derive the equation for this ambipolar transport event.