國立臺灣科技大學
八十八學年度碩士班招生考試試題

系所別：電子工程系碩士班 組別：丙組 科目：電磁學與固態電子學

九題全答

(一) 電磁學部份 (1-4, 共四題)

[1] 20% A long two-wire transmission line of length s is placed in a medium of permeability μ, permittivity ε, and conductivity σ. The wires are parallel to each other and carry currents in opposite directions.

(A) Find the **total inductance** and the **total leakage resistance** of the line if the distance D between centers of wires is much larger than the wire radius b. The internal inductance should be included.

(B) How can the signal **frequency** affects the total inductance of the line if b is not small compared with D?

[2] 7% Explain the **magnetic hysteresis** loop of ferromagnetic material which is good for use in electric transformers.

[3] 7% A homogenous isotropic **dielectric sphere** of radius c and relative permittivity ε_r=5 is placed in an initially uniform electric field $\vec{E}_o$. The medium outside the sphere is air. Draw qualitatively the **equipotential curves** and the directions of **electric fields** inside and outside the sphere.

[4] 16% A circular **disk** of radius c, conductivity σ, and thickness t (t<c) is placed in a magnetic filed $B\vec{k}$, where $\vec{k}$ is the unit vector in the z direction. The axis of the disk is in the z direction. Discuss and find

(A) the voltage which can be generated in the disk if B is constant and the disk is **rotating** about the z-axis with a constant angular velocity ω;

(B) the eddy current which can be generated in the disk if the disk is **fixed** in space **and** $dB/dt = b_o$, where b_o is a constant.

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(二) 固態電子學部份 (5-9, 共五題)

[5] 7% Calculate the approximate donor **ionization energy** for a semiconductor with relative permittivity ε_r=15, conductivity effective mass $m_c^*=0.1m_0$, and density of state effective mass $m_d^*=0.6m_0$, where m_0 is the free electron mass.

[6] 7% Sketch qualitatively and compare the **temperature** dependences of **Fermi levels** E_F in (A) the Si sample with donor impurity of 10^{16} cm^{-3} and (B) the Si sample with donor impurity of 10^{18} cm^{-3} for the temperature (T) range from T=50K to T=700K.

[7] 6% A Si sample is doped with Boron (硼) impurity of 10^{16} cm^{-3}. Sketch qualitatively the distributions of **electron** and **hole concentrations** as functions of **energy** at room temperature. The corresponding formula should be written. The positions of Fermi level, the conduction and valence band edges should be shown on the energy axis.

[8] 14% Draw the energy-band diagrams for the following structures :
(A) a **p-n junction** under a reverse bias; (The electron and hole quasi-Fermi levels should be shown in the figure.)
(B) an **Al-Si-Al structure** (n-type Si sample sandwiched between two pieces of Al(鋁)) with a temperature T_L at the left-hand-side Al and a temperature T_H at the right-hand-side Al, $T_H > T_L$. Assume that the work function of Si is larger than that of Al.

[9] 16% Consider a Ge p-n step junction **diode** with permittivity ε and doping concentrations N_a and N_d in the p- and n-regions, respectively. Find the **total current density** of the diode illuminated uniformly by light so that the carrier generation rate $g(m^{-3}s^{-1})$ is steady and uniform in the whole diode. **Given** that V= the voltage across the diode under low injection, T= temperature, k= Boltzmann constant, q= electron charge, n_i = intrinsic carrier concentration, τ_n= electron lifetime, τ_p= hole lifetime, D_n = electron diffusion coefficient, and D_p = hole diffusion coefficient.