# 國立中山大學106學年度碩士暨碩士專班招生考試試題

科目名稱：半導體概論【電機系碩士班甲組】　　題號：431012

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. The resistivity of a silicon bulk is reduced by 1.5 Ω-cm after doping $5\times10^{16}$ $cm^{-3}$ donor atoms. The electron mobilities of Si are 1300 and 1100 $cm^2$/V-s before and after the doping process. Calculate the initial electron density in this material before the donors are added. $T = 300$ K. (20%)

2. Tungsten (W) has a high melting point and can be used in semiconductor processing. It has body-centered cubic structure and the density is 19.25 $g/cm^3$. Each W atom has a mass of 183.84 amu. (1 amu = $1.66\times10^{-27}$ kg)
   (a) Determine the lattice constant of the cubic unit cell. Express your answer in angstrom.
   (b) If the atom in the center just touches the atoms at the corners of the cube, find the volume of each atom. (10%, 10%)

3. Answer the following questions about an *n-p-n* transistor.
   (a) Write down all the different modes of operation for this bipolar transistor. Describe the biasing conditions of each junction.
   (b) For each of the modes that you write, draw the minority carrier concentration profiles in emitter, base, and collector regions of the transistor. (10%, 10%)

4. A *p*-type GaAs is doped with $N_A = 5\times10^{16}$ $cm^{-3}$. Assume for the recombination lifetime of both electrons and holes are $\tau_n = \tau_p = 3\times10^{-7}$ s. The sample is under illumination resulting in a constant and spatially uniform generation rate of electron-hole pairs $G = 2\times10^{21}$ $cm^{-3}$ $s^{-1}$. $T = 300$ K.
   (a) Calculate the steady-state electron density.
   (b) Calculate the change in conductivity due to the illumination. The electron and hole mobilities are $\mu_n = 8500$ $cm^2$/V-s and $\mu_p = 400$ $cm^2$/V-s, respectively. (10%, 10%)

5. For an abrupt $p^+$-*n* silicon diode, the doping concentration in the *n*-region is $5\times10^{16}$ $cm^{-3}$. The width of the *n*-region is 3 μm. Assuming this width is much smaller than the hole diffusion length. Calculate the reverse saturation current at 300 K. The area of the diode is 100μm× 100μm and the hole mobility is 350 $cm^2$/V-s. (20%)