Exercise Solid-State Physics (ET2908 and 8027) 2009-20010Q1: dr. R. Ishihara, DIMES-TC00.0044, r.ishihara@tudelft.nl

Exercise-sheet 7

I. Density of States Function

(I.1) Consider free electron in a 2D box with a width of a. The allowed wave-numbers k_x and k_y for x and y directions respectively are expressed as $\frac{\pi n_x}{a}$ and $\frac{\pi n_y}{a}$ where $n_x, n_y = 1, 2, 3, ...$ The figure **??** shows the schematic view of the 2D array of allowed quantum states in k-space.

(1) Determine the area in k-space occupied by one allowed k point.

(2) Express number of allowed states in the area enclosed by the first quatorant circles with the radius of k and $k + dk$, where $k \gg dk$.

(3) Express density of allowed states in real space per unit energy.

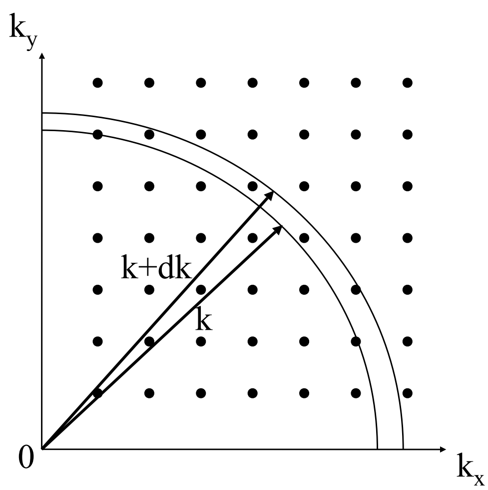

Figure 1: 2D array of allowed quantum states in k-space

(I.2) Determine the total number of energy states in Si (a) between E_c and $E_c + kT$ at $T = 300K$, and (b) between E_v and $E_v - kT$ at $T = 300K$.

II. Statistical Mechanics

(II.1) Assume the Fermi energy level is exactly in the center of the bandgap energy of a semiconductor at $T = 300$K.

(a) Calculate the probability that an energy state in the bottom of the conduction band is occupied by an electron for Si and Ge.

(b)Calculate the probability that an energy state in the top of the valence band is empty for Si and Ge.

(II.2) Neaman Problem 3.36