Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Haust 2017

Eðlisfræði þéttefnis I

Dæmablað 11

Skilafrestur 23. November 2017 kl. 15:00

1. **Snertimætti p-n-skeyta – Built-in potential for a p-n-junction** (10)

   Finna skal snertimætti fyrir kísil p-n skeyti við stofuhita ef boleðlisviðnám kísils er 1 Ω cm. Hreyfanleiki rafeinda í kísili er 1400 $\mathrm{cm}^2/\mathrm{Vs}$; $\mu_\mathrm{n}/\mu_\mathrm{p} = 3.1$; og $n_\mathrm{i} = 1.05 \times 10^{10}$ cm^{-3}.

   Find the built-in potential for a p-n Si junction at room temperature if the bulk resistivity of Si is 1 Ω cm. Electron mobility in Si at RT is 1400 $\mathrm{cm}^2/\mathrm{Vs}$; $\mu_\mathrm{n}/\mu_\mathrm{p} = 3.1$; and $n_\mathrm{i} = 1.05 \times 10^{10}$ cm^{-3}.

   (Próf desember 2016)

2. **Fermi surfaces in two dimensions** (10)

   Consider a two-dimensional system of nearly free electrons (weak periodic potential) with a square unit cell (lattice constant a). Determine the Fermi surfaces for the cases of 1, 2, 3, and 5 electrons per unit cell. To this end, first project the free electron Fermi surface into the 1st Brillouin zone and then think about at what points gaps open. Plot the Fermi surfaces in the Brillouin zone. It might be useful to make separate plots for the different bands. (Note: Semi-quantitative plots are OK, i.e., you need to get the topology right, the exact positions are not so important.)

3. **Hall effect** (10)

   A sample of $n-$type GaAs whose carrier concentration is 10^{16} cm^{-3} is in the shape of a slab whose length is 5 cm, width 0.5 cm, and thickness of 1 mm. When this

slab is palced in a magnetic field of 0.6 Wb/m^2 normal to the slab, with a current of 10 mA. Calculate

(a) The Hall constant in this sample

(b) The Hall voltage developed across the slab.

4. **Empty lattice or free electron model** (10)

(a) Construct the first, second and third Brillouin zones for a two dimensional square lattice crystal of lattice constant a. In the free electron approximation, what is the number of electrons per unit cell needed for the third Brillouin zone to start being filled

(b) Consider a monovalent simple cubic crystal and calculate the fraction of substitutions with bivalent atoms required for the Fermi surface to touch the boundary of the first Brillouin zone.

(c) In a FCC crystal with conventional lattice constant a = 0.4 nm, what is the energy difference between the lowest and next lowest bands at the center of the first Brillouin zone.

(d) Determine if the Fermi surface of a monovalent BCC crystal lies within the first Brillouin zone.