Solid State Electronics (EE113FZ)

Tutorial 3

Electronic Materials, Conduction Models & Crystal Structure

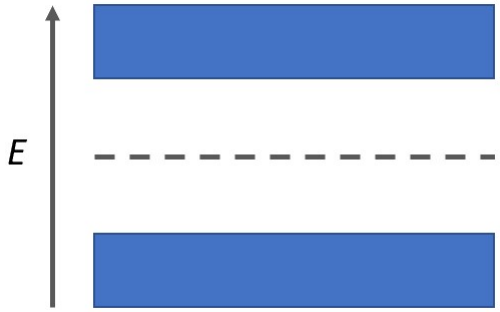
Answer the following questions.

1. Name the three different types of electronic materials.

2. List 3 physical properties of good electrical conductors.

3. In terms of energy levels explain the difference between an insulator and a semiconductor.

4. What are the 3 main parts in the energy diagram below? Redraw this diagram to show a conductor.



5. Aluminum has the face-centred cubic (FCC) structure with a lattice parameter of 4.05 Å. Estimate the conduction electron density of aluminum and its Hall coefficient. Hint: refer to the periodic table for the electron shell structure of aluminum.

6. Copper has a resistivity of 1.7×10^{-8} Ω·m at room temperature.
   (1) What is copper's conductivity at room temperature?
   (2) Make an estimate of the electron relaxation time and mobility in copper by applying the free-electron Drude model (Copper has the FCC structure with a lattice parameter of 3.63 Å and it can be treated as a divalent element).
   (3) What is the electron drift velocity when an electric field of 20 V/m is being applied to a copper wire at room temperature?

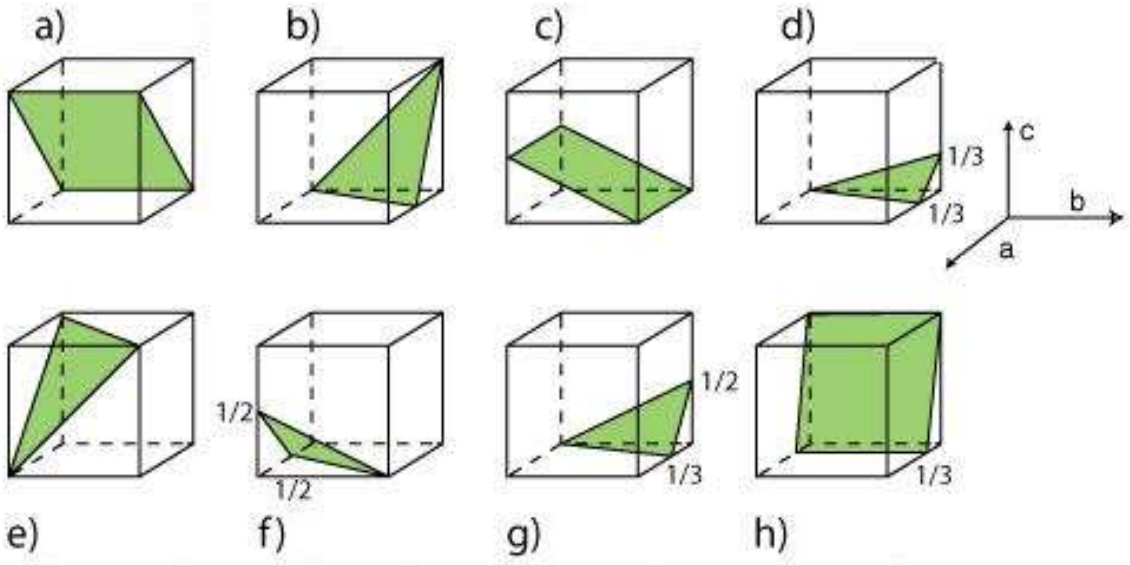
7. Explain in the language of the Drude model where the electrical resistance of a conductor comes from.

8. The lattice constant for silicon is 5.431 Å. Calculate the volume of a silicon unit cell in m^3 and cm^3. Silicon crystalizes in the same structure as diamond (two interpenetrating FCC cells). Calculate the density of silicon. Take the atomic weight of silicon to be 28.

9. Draw a primitive cubic unit cell and label crystal planes with Miller indices (100), (110), and (111).

10. Silicon has the same crystal structure as diamond (two interpenetrating FCC cells) and its lattice constant is 5.431 Å. Determine the density of atoms on its (100), (110), and (111) planes.

11. Provide the Miller indices of the following crystal planes.



12. In the Drude model, the probability of an electron experiencing a collision event per unit time is $1/\tau$ in which τ (measured in seconds) is the relaxation time. Show that the probability for an electron to have no collision in the next *t* seconds is exp(-t/τ). Hint: you may need the limit definition of the exponential function: $e^x = \lim_{n\to\infty}\left(1+\frac{x}{n}\right)^n$ (which you should have learnt in your calculus class). You can skip this question if you feel that it is too difficult.