HW1
Pete Mills
Sept 7, 2023

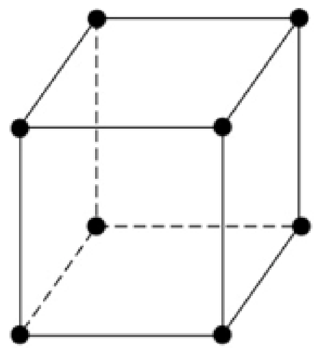
Problem 1

Ridha Kamoua posted Aug 20, 2023 7:27 PM   Subscribe

Problem 1

(a) A simple cubic structure consists of a single atom in the center of the cube. The lattice constant is a_0. Determine the volume density of atoms and the surface density of atoms in the (110) plane.

(b) Compare the results of part (a) to the results for the case of the simple cubic structure shown below with the same lattice constant.



a) ρ_{bcc} = 2 atoms / a_0^3, σ_{bcc} = 5atoms / a_0^2

b) ρ_{sc} = 1 atoms / a_0^3, σ_{sc} = 0.5atoms / a_0^2,

Therefore,
BCC structure has 2x the volume density as SC structure.
BCC structure has 10x the surface density of SC structure.

Problem 2

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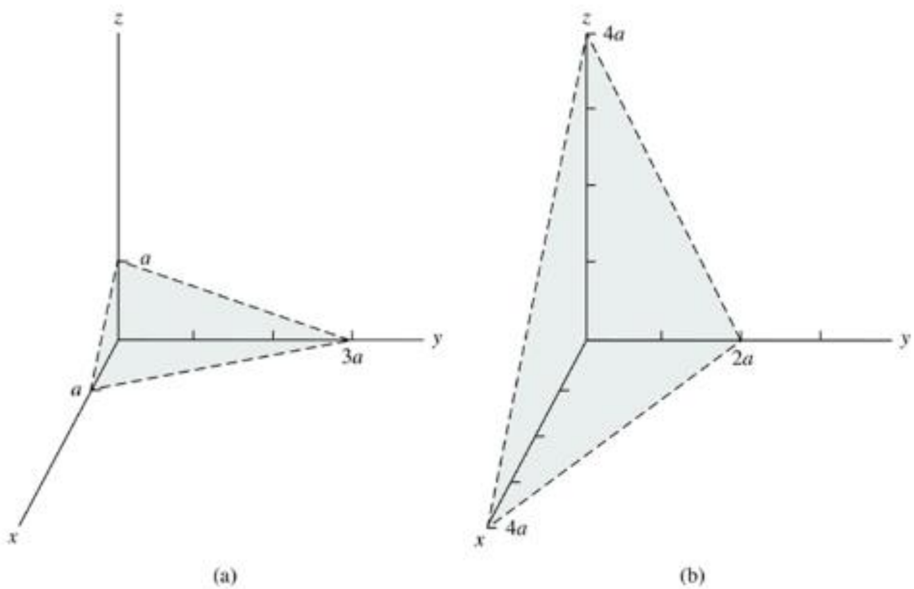
Problem 2

For a simple cubic lattice, determine the Miller indices for the planes shown in the figure below.



a) p=1, q=3, s=1 -> (1/1, 1/3, 1/1) -> (3/3, 1/3, 3/3) -> (3, 1, 3)

b) p=4, q=2, s=4 -> (1/4, 1/2, 1/4) -> (1/4, 2/4, 1/4) -> (1, 2, 1)

Problem 3

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Problem 3

Calculate the de Broglie wavelength for

a) An electron with kinetic energy of

i. 1.0 eV

ii. 100 eV

b) A proton with kinetic energy of 1 eV.

eeo-331 > hw > hw1 > broglie.py > ...

```python
import numpy as np

# Planck's constant J/s
h = 6.62607015e-34

# Define 1 eV in Joules
eV_to_Joules = 1.60219e-19

def calculate_de_broglie_wavelength(mass_kg, kinetic_energy_J):
    # Calculate momentum from kinetic energy and mass
    momentum = np.sqrt(2 * mass_kg * kinetic_energy_J)
    # Calculate Broglie wavelength using momentum
    wavelength = h / momentum
    return wavelength

# Input parameters
mass_proton_kg = 1.6726219e-27  # Mass of a proton in kilograms
mass_electron_kg = 9.10938356e-31  # Mass of an electron in kilograms
energies = [1.0, 100.0]  # Kinetic energy in electronvolts

for kinetic_energy_eV in energies:
    # Convert kinetic energy from eV to Joules
    kinetic_energy_J = kinetic_energy_eV * eV_to_Joules

    # Calculate Broglie wavelengths
    wavelength_electron = calculate_de_broglie_wavelength(mass_electron_kg, kinetic_energy_J)
    wavelength_proton = calculate_de_broglie_wavelength(mass_proton_kg, kinetic_energy_J)

    # Print results
    print(f"Broglie wavelength for an electron with {kinetic_energy_eV} eV kinetic energy: {wavelength_electron:.6e} meters")
    print(f"Broglie wavelength for a proton with {kinetic_energy_eV} eV kinetic energy: {wavelength_proton:.6e} meters")
```

PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL   GITLENS

```
pete@pete-Precision-5550:~/code/eeo$ ls
books  eeo-224  eeo-315  eeo-331  eeo-352  README.md
pete@pete-Precision-5550:~/code/eeo$ cd eeo-331/hw/hw1/
pete@pete-Precision-5550:~/code/eeo/eeo-331/hw/hw1$ ls
bandgap.py  broglie.py
pete@pete-Precision-5550:~/code/eeo/eeo-331/hw/hw1$ python ./broglie.py
Command 'python' not found, did you mean:
  command 'python3' from deb python3
  command 'python' from deb python-is-python3
pete@pete-Precision-5550:~/code/eeo/eeo-331/hw/hw1$ python3 ./broglie.py
Broglie wavelength for an electron with 1.0 eV kinetic energy: 1.226421e-09 meters
Broglie wavelength for a proton with 1.0 eV kinetic energy: 2.862102e-11 meters
Broglie wavelength for an electron with 100.0 eV kinetic energy: 1.226421e-10 meters
Broglie wavelength for a proton with 100.0 eV kinetic energy: 2.862102e-12 meters
pete@pete-Precision-5550:~/code/eeo/eeo-331/hw/hw1$
```

Problem 4

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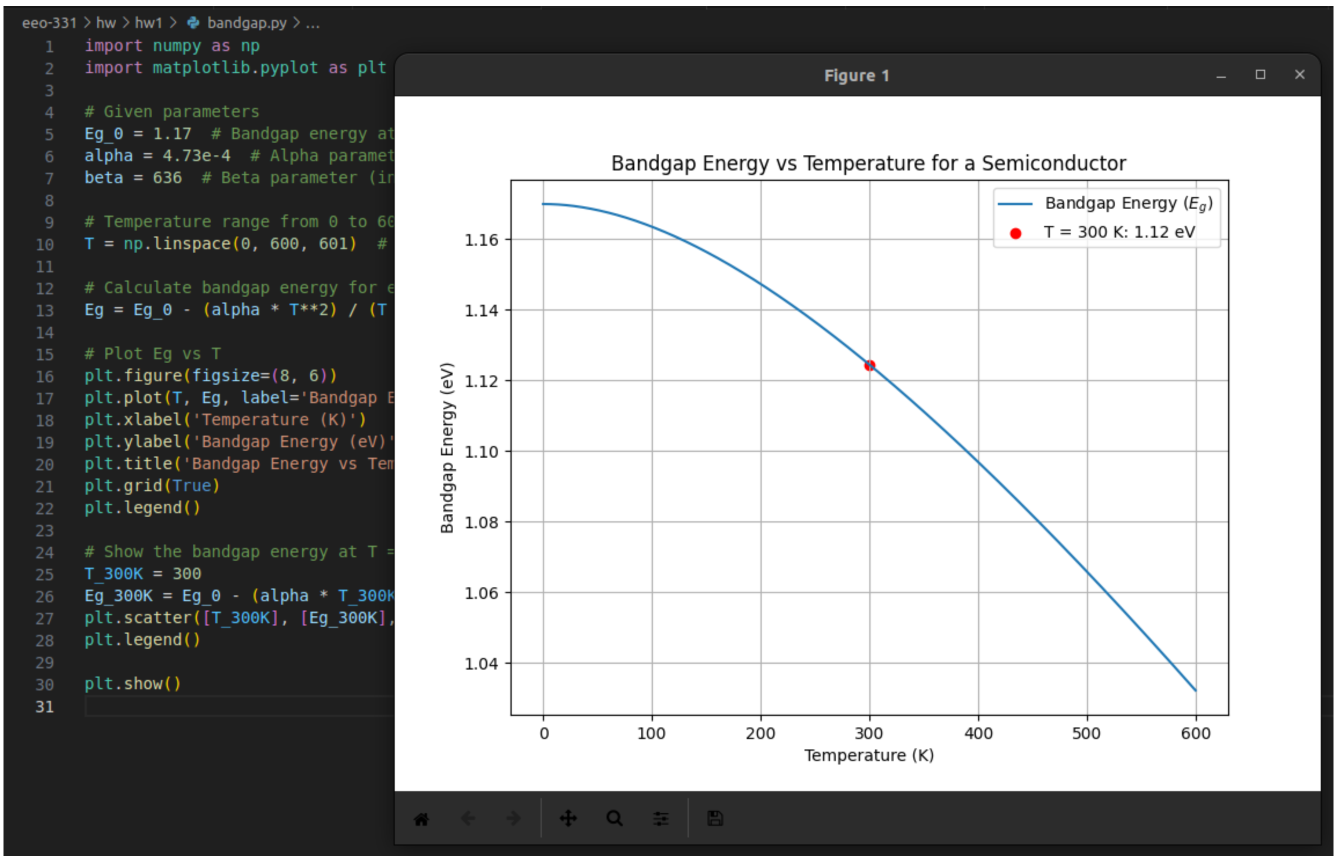
Problem 4

The bandgap energy in a semiconductor is usually a slight function of temperature. In some cases, the bandgap energy versus temperature can be modeled by

$$E_g = E_g(0) - \frac{\alpha T^2}{(\beta + T)}$$

Where $E_g(0)$ is the value of the bandgap energy at T = 0 K. For silicon, the parameter values are $E_g(0) = 1.17$ eV, $\alpha = 4.73\text{x}10^{-4}$eV/K and $\beta = 636$ K. Plot E_g versus T over the range $0 \le T \le 600\ K$. In particular, note the value at T = 300 K.



Problem 5

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Problem 5

The forbidden energy band of GaAs is 1.42 eV.

a) Determine the minimum frequency of an incident photon that can interact with a valence electron and elevate the electron to the conduction band.
b) What is the corresponding wavelength?

E=hf
E=1.42eV×1.60217663×10−19J/eV
f_min = E/h
f_min = E/6.62607015×10−34
f_min = 2.854×10^14Hz is the minimum frequency of an incident photon.

Lambda = c/f_min where c = 3e^8m/s
Lambda = 1.05e^-6 m is the corresponding wavelength.