

OPTI 507 - Midterm Exam
Fall 2004
100 Points Possible

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1 Problem 1 - 25 Points

- (a) (5 Points) Write down the dielectric function for longitudinal waves.
- (b) (5 Points) Write down the dielectric function for transverse waves.
- (c) (10 Points) Using the following dielectric function of the oscillator model, show that alkaline metals are good reflectors of visible light:

$$\epsilon(\omega) = \epsilon_{\infty} - \frac{4\pi ne^2\tau}{m_e\omega} \frac{\omega\tau - i}{\omega^2\tau^2 + 1}, \quad (1)$$

where $\epsilon_{\infty} = 1 + 4\pi \frac{P_b}{E_0}$. To do this, consider Eq. 1 in the high frequency regime ($\omega\tau \gg 1$).

- (d) (5 Points) Using Eq. 1 in the high frequency regime, how does metals respond to UV light? Why?

2 Problem 2 - 15 Points

Derive the scattered photon energy and momentum for a coherent Stokes Raman scattering (CSRS) process. You may want to use energy and momentum diagrams to describe this process.

3 Problem 3 - 15 Points

Using the momentum conservation in Brillouin scattering, determine the magnitude of the acoustic phonon energy. Use a speed of sound of 3×10^5 cm/s and 2 eV photons.

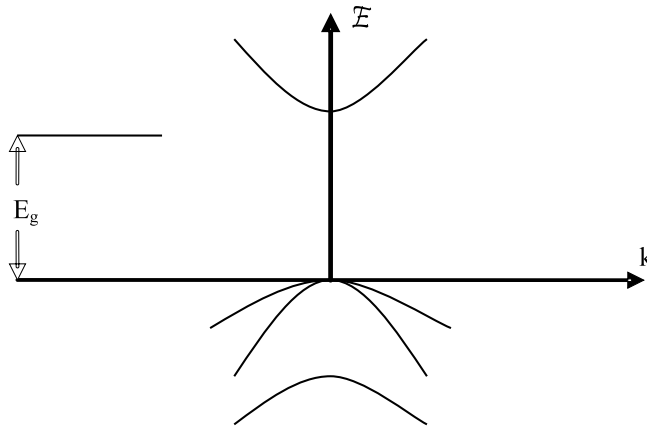


Figure 1: The band-structure diagram for Problem 4 (b).

4 Problem 4 - 10 Points

- (a) (5 Points) Draw a sketch of phonon-polariton dispersion curves.
- (b) (5 Points) Draw sketches of the real and imaginary parts of the electric susceptibility for a Lorentz oscillator in the vicinity of an optical resonance at ω_0 .

5 Problem 5 - 35 Points

- (a) (5 Points) Silicon cannot be used make a good light source. Why not?
- (b) (10 Points) Is it possible to have direct transitions in indirect-bandgap semiconductors? Why or why not? If it is possible, then sketch the process.
- (c) (10 Points) Figure 1 shows the band-structure of GaAs near $k = 0$. Label each band as a conduction or valence band. For the bottom three bands, label the relative electron/hole effective-mass (i.e., which is the lightest, middle, and heaviest ignoring sign).
- (d) (10 Points) Assume a flux of $I_0 = 1 \text{ W/cm}^2$ is incident on a $L = 1 \text{ }\mu\text{m}$ -thick wafer of a semiconductor. Using the Beers' law determine how much of the light gets transmitted through the wafer assuming that the semiconductor absorption coefficient is $\alpha = 10,000 \text{ cm}^{-1}$.