

Task 1

Semiconductor Physics I WS 2021/22

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Day of issue: 08. November 2021

Deadline: 22. November 2021

The solutions have to be in a readable format. Please write your name and Matrikelnummer on each page, otherwise the tasks will not be assessed. Please, hand in your solutions on Monday, 22. November, after the lecture (SR532) (until 15:00 o'clock).

T1. Calculate for the orthorhombic crystal structure of SrRuO₃ the angle between the [102]-direction and the (102)-plane ($a = 0.553$ nm, $b = 0.557$ nm and $c = 0.785$ nm). How large is the angle if all lattice constants have the same length, i.e., $a = b = c$? **[7 points]**

T2. The dispersion of the phonons in a monoatomic linear chain is given by

$$\omega(k) = 2 \sqrt{\frac{C}{M}} \sin\left(\frac{ka}{2}\right). \quad (\text{T2.1})$$

M and C are the mass of the atoms and the force constant, respectively. Calculate the density of states ($D(E)$) and consider that energy of the photon is given by

$$E_{\text{ph}}(k) = \hbar\omega(k). \quad (\text{T2.2})$$

[5 points]

T3. Consider a monoatomic linear chain. An impurity (mass defect) with a smaller mass ($M' < M$, identical force constant C) causes a local vibrational mode.

Show, that the displacement decreases exponentially with increasing distance from the mass defect. (Hint: Use the Ansatz, that the displacement amplitude is proportional to $B^{|n|}$, where M' is situated on place $n = 0$.)

What is the frequency of this local mode (as a function of C , M , and M')?

Assuming a boron impurity in silicon: What is the relative difference in energy for ^{10}B and ^{11}B ? Compare this to the experimental values of 80.2 meV and 77.2 meV. Estimate the spatial expansion of this mode.

[9 points]

T4. An In_{0.2}Ga_{0.8}As layer was pseudomorphically grown on a thick (110)-oriented GaAs substrate. For the [110] direction is the ratio of the stress perpendicular and parallel to the interface given by:

$$\frac{\epsilon_{\parallel}}{\epsilon_{\perp}} = -\frac{C_{11} + 3C_{12} - 2C_{44}}{C_{11} + C_{12} + 2C_{44}} \quad (\text{T4.1})$$

Which condition for C_{44} have to be fulfilled, so that cubic material behaves isotropically with respect to biaxial stress? (Hint: Consider at first the growth on a (001)-oriented GaAs substrate.

[6 points]

Total:

27 points