Tfy-3.4311 Materials Physics II Examination 24.10.2012 (1st midterm)

Explain the concepts that you use in your answers. All the figures are on the next page, after the problems.

1. In an intrinsic semiconductor the effective mass of holes in the valence band is smaller than that of electrons in the conduction band. Where is the Fermi level at very low temperatures? How does it behave when the temperature rises? (2 p)

2. How does the mobility of charge carriers behave in doped semiconductors as a function of temperature? Why? (2 p)

3. Explain the trends seen in Figure 1! What are the consequences for device design? (4 p)

4. What is the quasi Fermi level for a biased pn junction? Why can it be defined? How can it be used to determine the charge carrier densities? (3 p)

5. Modulation-doped heterstructures.
   a) Explain the physical phenomena involved in the formation of the band structure depicted in Figure 2! (2 p)
   b) What physical phenomena do you see in the measured results shown in Figure 3? (2 p)

6. Paramagnetism of the gas of paramagnetic ions. Explain the main principles preferably with equations (Ground state of ions, effect of the external magnetic field, free energy and susceptibility as a function temperature! How well the theory describes ions with open 3d or 4f electron shells. Why? (5 p)

7. Stoner criterium for ferromagnetism. In what kind of materials it predicts ferromagnetism? Why? How it can be used to predict the temperature dependence of magnetization? (4 p)

8. Figure 4 compares the mean-field model with magnetization values measured for Ni. Where are theory and experiment in disagreement and why? (3p)

8. The domain structure of a ferromagnet. Why it exists? What determines the thickness of the Bloch walls between the domains (3 p)

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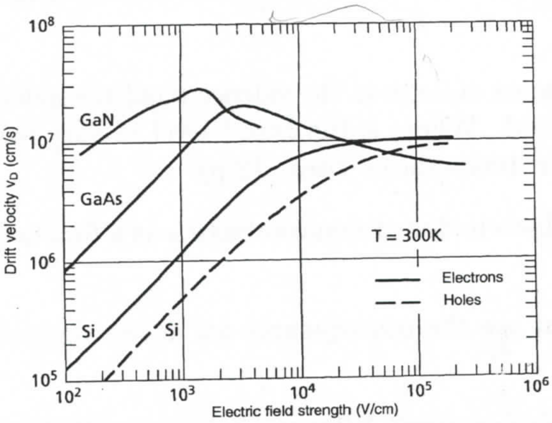

Fig. 12.15. Carrier drift velocity v_D at 300 K as a function of electric field $\mathcal{E}$. The data for Si and GaAs are from a compilation (Sze [12.4]) of experimental results on highly pure, crystalline samples. The curve for GaN is calculated by means of Monte Carlo simulations (after Gelmont et al. [12.5])

Figure 1.

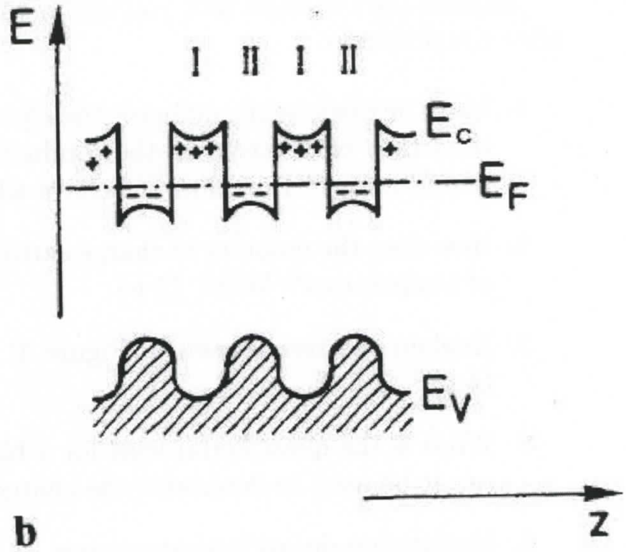

Figure 2.

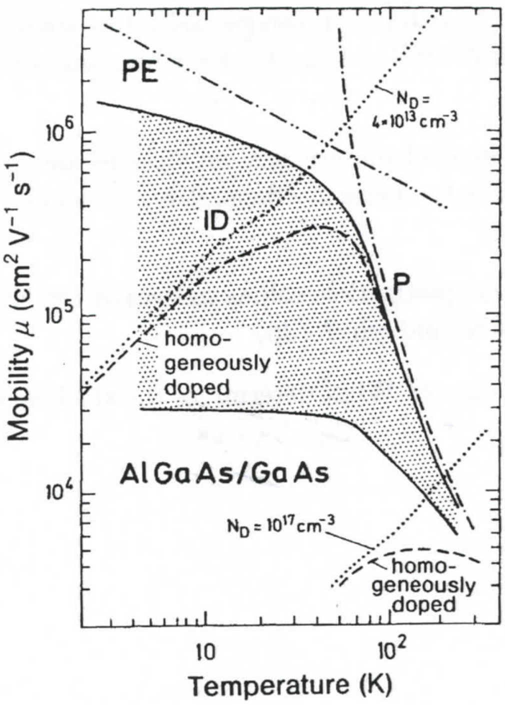

Figure 3.

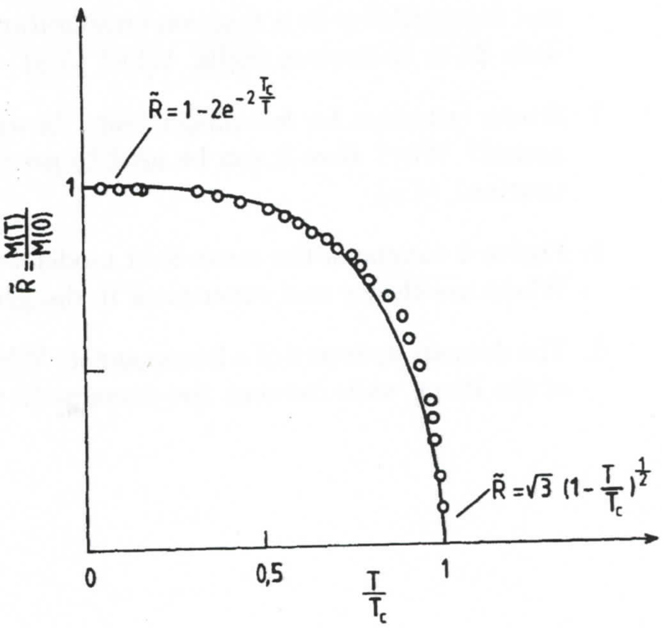

Figure 4.