École Polytechnique Fédérale de Lausanne

SEMICONDUCTOR PROPERTIES AND RELATED NANOSTRUCTURES

MSE-484

Exercise session 2

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1 - Doped semiconductors

1. III-V alloys such as InGaAsN can be p-doped with atoms from group II (Mg, Be) and n-doped with atoms from group VI (S, Se, Te). Which kind of doping do you expect from Si? Comment on the answer and describe qualitatively how the carrier concentration changes with increasing Si concentration.

2. Derivate the expression for E_F vs. T in different regimes. What is the physical meaning of the degeneracy factor?

3. Define the doping regimes in the graph below.

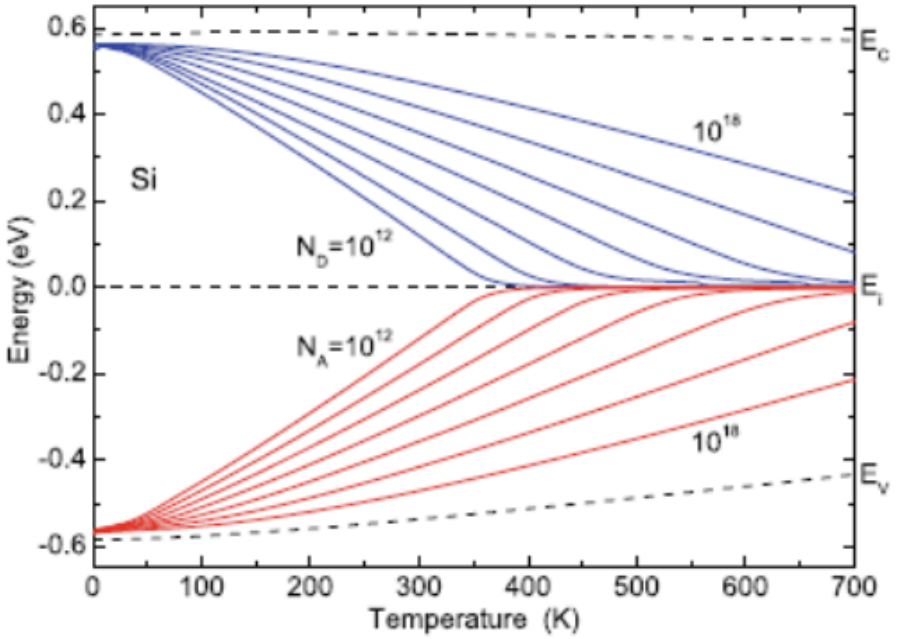

Figure 1: Fermi level in silicon as a function of temperature for various doping levels.

2 - Optics

We discovered a new semiconductor and we experimentally measure α as a function of $\hbar\omega$.

1. How do we measure if our material is a direct or indirect semiconductor?
2. Can we estimate the band gap? If so, how?
3. Which absorption coefficient would you expect for amorphous semiconductors? Why?
4. Look at the plot in Fig. 2. Can you explain the evolution of the absorption coefficient with the energy of incident photons?

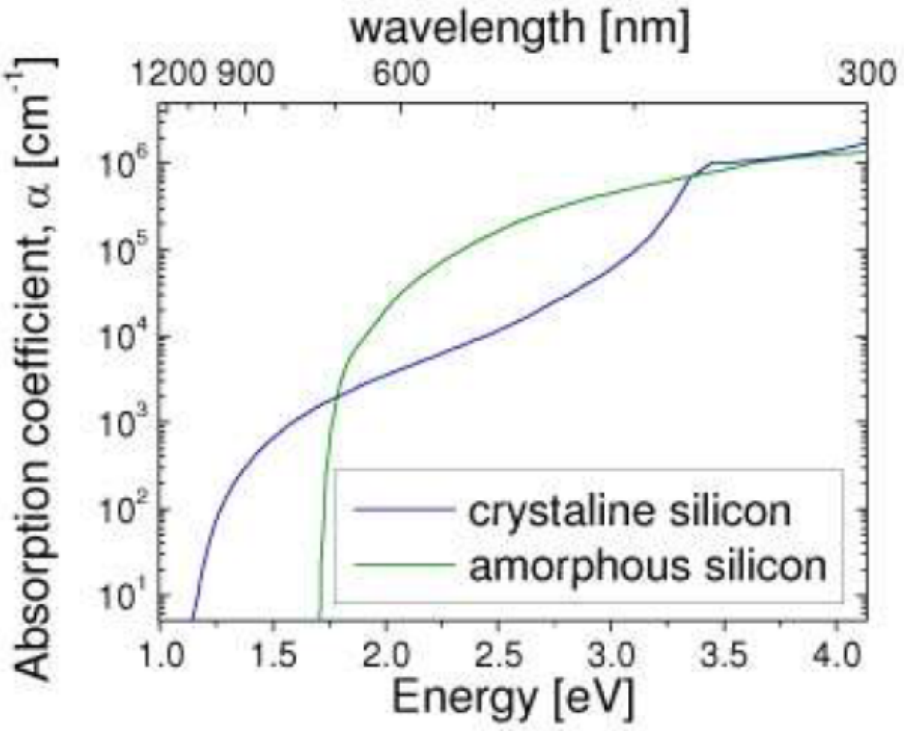

Figure 2: Absorption coefficient, α, as a function of E and λ.

3 - Electrical conductivity vs. T

The figure 3 (a) depicts the electrical conductivity of a semiconductor as a function of the inverse temperature.

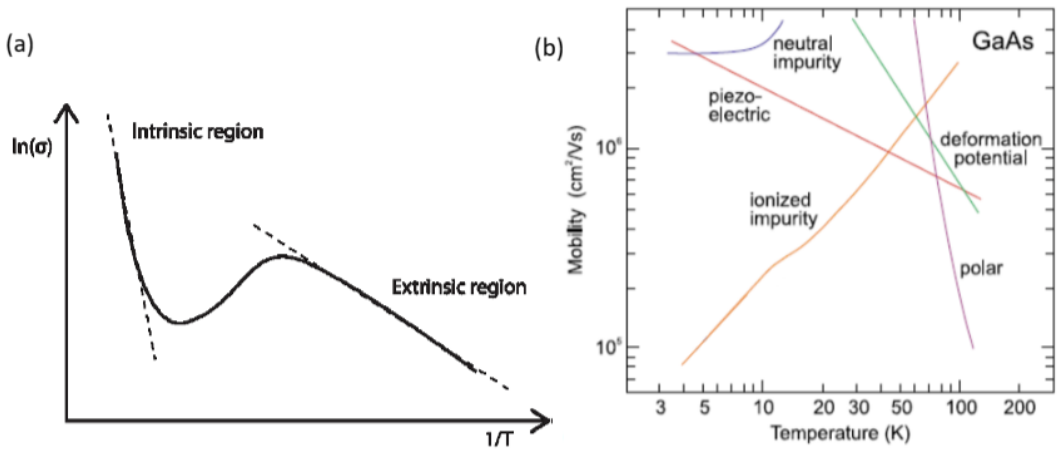

Figure 3: (a) Logarithm of conductivity as a function of $1/T$. (b) GaAs mobility as a function of T.

1. Describe the figure and explain the dependence.

   Consider GaAs mobility as a function of temperature, as shown in figure 3 (b).

2. Can you estimate the total mobility of GaAs as a function of T.
3. How can we improve the mobility? Which mechanism can we suppress?