Carrier Mobility in Semiconductors at Very Low Temperatures

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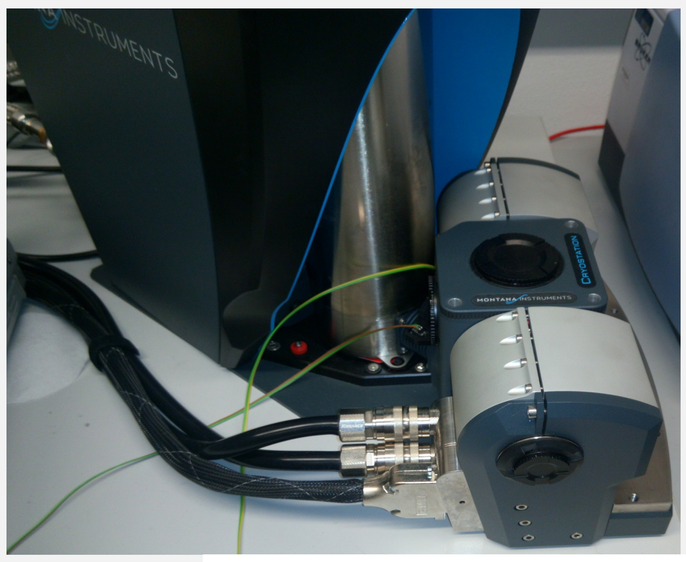
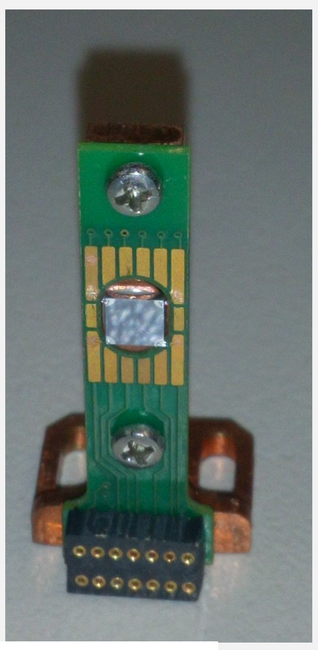
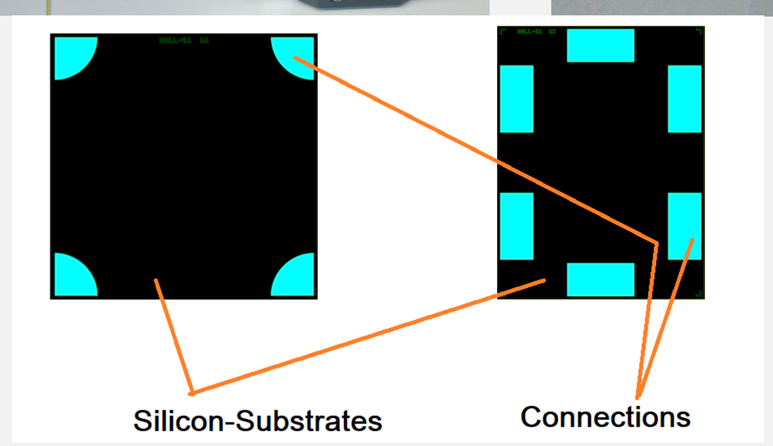
Motivation

The aim is to obtain better data on mobility and concentration for electrons and holes in silicon at very low temperatures. These data will be used to improve current simulation models for semiconductors in this temperature range.

Experimental Setup

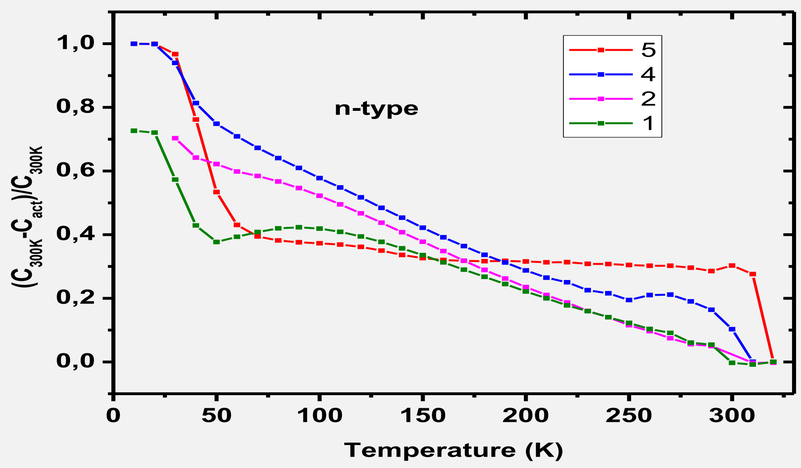


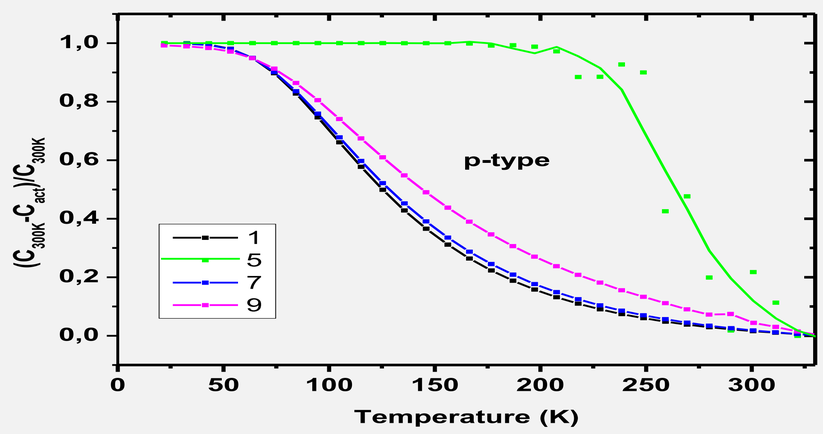




Top: Cryostation with magnetic coils and specimen holder
Bottom: Typical Hall-structures, used for the measurements at CiS

Meassured carrier concentrations



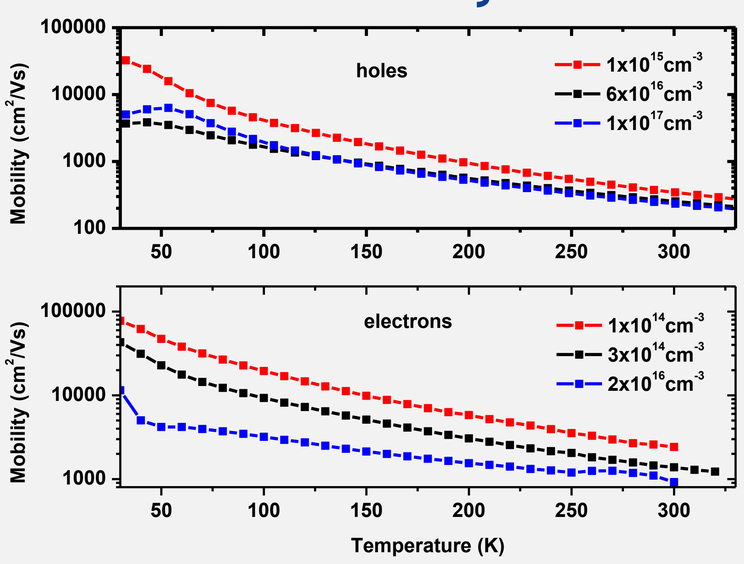


Measured carrier concentration (relative values) of various n- and p-type silicon materials in dependence on the temperature. The relative values are the actual concentration at temperature T in relation to room temperature values ($(C_{300K} - C_{act})/C_{300K}$).

n-type materials (1) $1 \cdot 10^{18}$ cm^{-3},(2) $1 \cdot 10^{18}$ cm^{-3},(4) $1 \cdot 10^{16}$ cm^{-3} and (5) $2 \cdot 10^{13}$ cm^{-3} at room temperature

p-type materials (1) $2 \cdot 10^{16}$ cm^{-3}, (5) $2 \cdot 10^{12}$ cm^{-3}, (7) $2 \cdot 10^{16}$ cm^{-3} and (9) $3 \cdot 10^{16}$ cm^{-3} at room temperature

Electron and hole mobility in silicon



Temperature-dependent hole(top) and electron mobilities (bottom) of silicon with different doping levels specified in the figure.

Summary and conclusion

In the temperature range 0.3 K ≤ T ≤ 300 K simulations show that experimentally determined carrier mobilities are best described in this temperature range by Klaassen´s model. Freeze out, however, depends on the dopant type and initial concentration. Semi-classical calculations are useful only for temperatures above 100K. Otherwise quantum mechanical calculations are required.

Acknowledgement

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