11. Tutorial on Optical Sources and Detectors

July 17th 2012

Problem 1: Dynamic of a pin-diode

a) How does absorption in the contact region and diffusion zone affect the bandwidth of a photodiode?
b) Why is it preferable for a fast photodiode to be operated with a reverse bias?
c) How can unwanted absorption in the respective areas of a pin-diode be avoided?

Problem 2: Operation principle of an avalanche photodiode (APD)

Figure 1 shows the basic structure of an APD, which consists of four layers, a highly n-doped (width d_n), the intrinsic absorption zone (width w_{ab}), another lesser n-doped layer (width w_{av}) and a highly p-doped layer (width d_p).

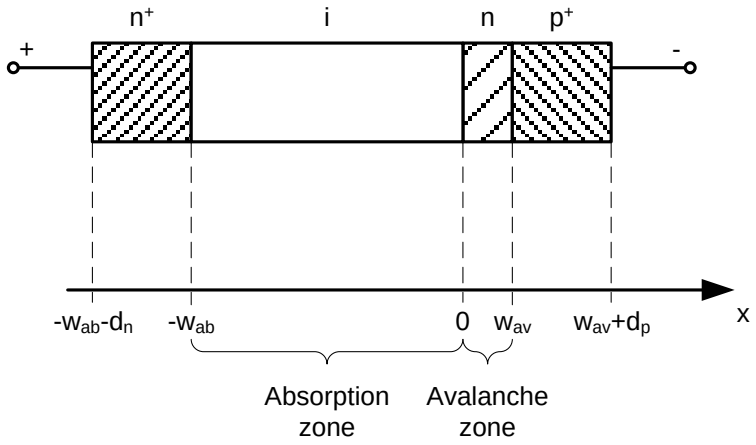

Figure 1 Schematic of an APD

a) Sketch the space charge density and the E-field profile as a function of x for partially and fully depleted avalanche zone. Assume that all donor/acceptor impurities are ionized ("Störstellenerschöpfung") and that there are no space charges within the absorption zone. Further assume that the depletion approximation holds and the dielectric constant ε_r is the same for all layers .
b) Using the sketch of part a) explain the operation principle of an APD.
c) What is an ionization coefficient? What is the qualitative dependence of the ionization coefficients on the electric field?
d) What can you tell about the relation between the change Δu of the bias voltage and the change ΔE_m of the maximum E-field strength? Regard two cases as in part a).
e) What is the meaning of the avalanche multiplication factor M_0? Explain the kink in Figure 2, which shows M_0 for different operation temperatures as a function of applied voltage.

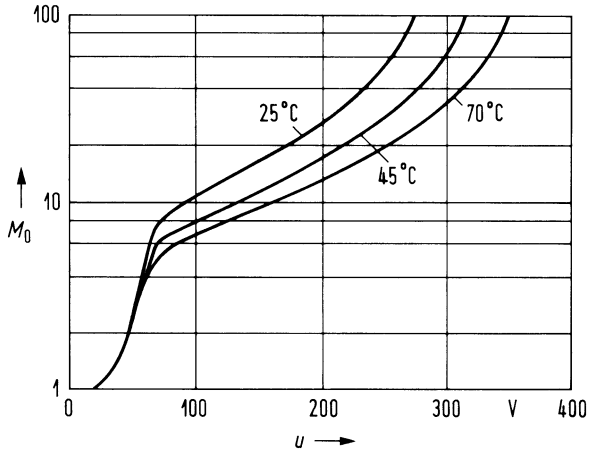

Figure 2 Avalanche multiplication factor as a function of the bias voltage, for different operation temperatures.

Questions and Comments:

Matthias Lauermann
Building: 30.10, Room: 2.23
Phone: 0721/608-48954
Email: Matthias.Lauermann@kit.edu

Jörg Pfeifle
Building: 30.10, Room: 2.23
Phone: 0721/608-48954
Email: Joerg.Pfeifle@kit.edu