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A simulation of transient photo-Hall effect **for recognition of defects** **in oxygenated Si.**

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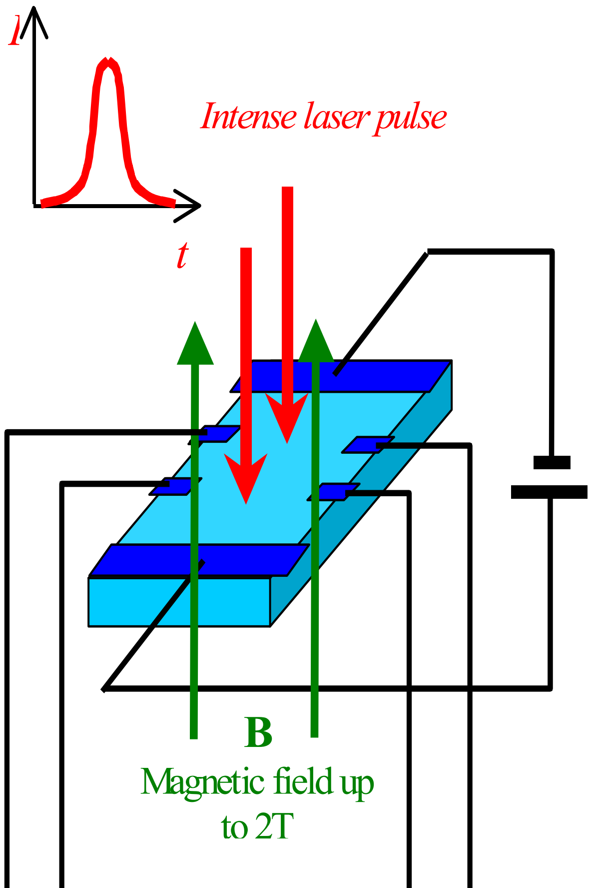
Outline:

- A principle
- Results of simulation
- Examples in a model material
- Samles needed

Photo-Hall effect



Digital processing:

High input impedance, small capacitance !

$$E_H(t) = \frac{\sum_i (-1) e_i n_i(t) A_i \mu_i^2(t)}{\sum_i |e_i| n_i(t) \mu_i(t)} B E_x$$

$$|\Delta U_H(t)| = w\left[E_{H0} - E_H(t)\right]$$

$$\frac{\Delta U_H}{kw} = \mu_H - \mu_{0H}$$

Transient Photo-Hall: 1. Basic relationships:

$$\frac{1}{\mu_H(t)} = \frac{1}{\mu_0} + \beta v S(t) N(t)$$

$$\Delta(SN) = S_0 N_0 - SN = \frac{1}{\beta v}\Delta\left(\frac{1}{\mu_0} - \frac{1}{\mu(t)}\right) = \frac{wBE}{\beta v U_{H0}}\left(1 + \frac{U_{H0}}{\pm \Delta U_H}\right)^{-1}$$

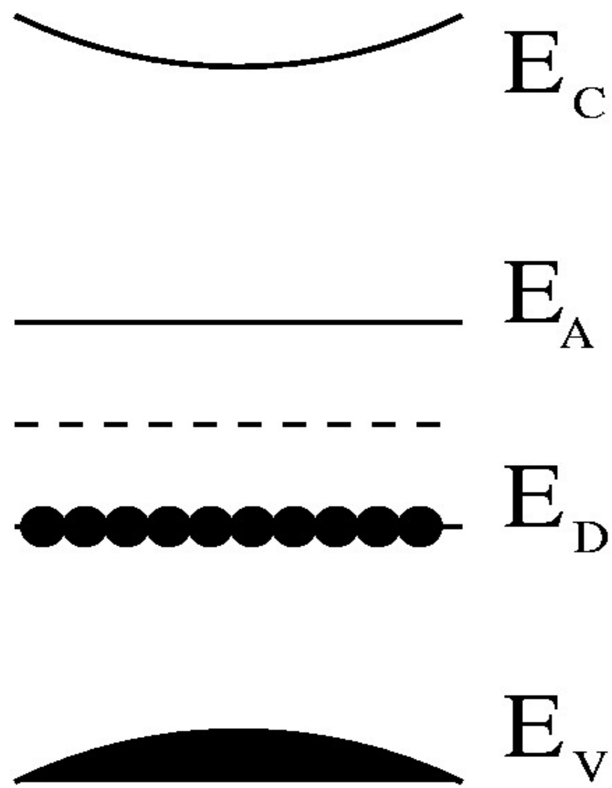
$$Y(t) = \left(1 + \frac{U_{H0}}{\Delta U_H}\right)^{-1} \qquad \Delta\left[S(t)N(t)\right] = const \cdot Y(t)$$

$$\frac{d\,n}{d\,t} = g(t) + \sum_i \gamma_{ci}\ \left((n_{1i} + n_0 + \delta n)\ \delta m_i\ -\ (N_i - m_{0i})\ \delta n\right)$$

$$\frac{d\,m_i}{d\,t} = -\gamma_{ci}\ \left((n_{1i} + n_0 + \delta n)\ \delta m_i\ -\ (N_i - m_{0i})\ \delta n\right) - \gamma_{vi}\ \left((p_{1i} + p_0 + \delta p)\ \delta m_i\ +\ m_{0i}\ \delta p\right)$$

$$\delta p = \delta n + \sum_i \delta m_i$$

System of model equations for the change of the band (*n*) and impurities (m_i) electron concentrations.



Normal state, thermal equillibrium.

Deep donor $E_D = E_V + 0.23$ eV

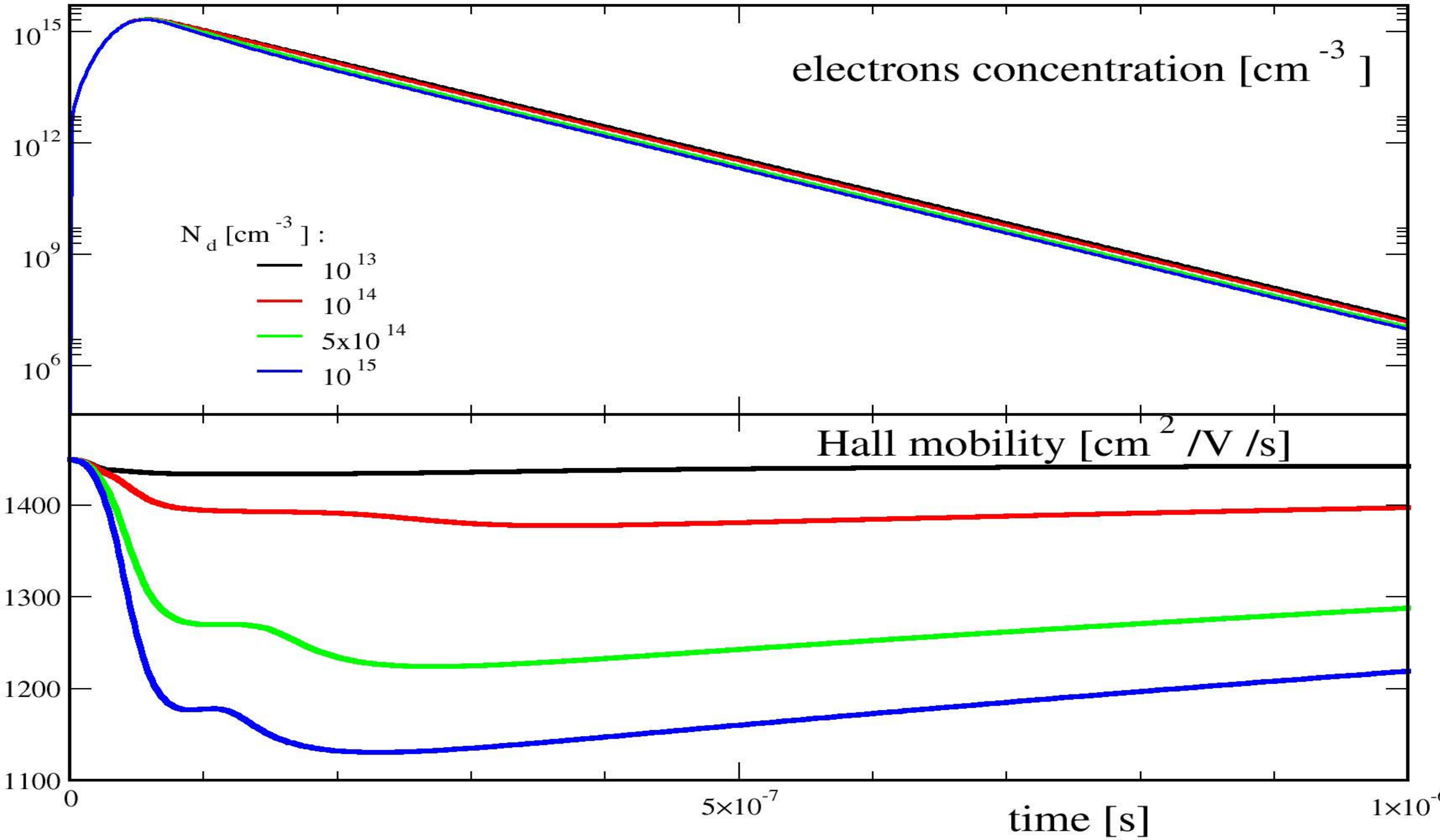
Deep acceptor $E_A = E_C - 0.545$ eV, $\sigma_{AC} = 1.7\ 10^{-15}$ cm^{-2}, $\sigma_{AV} = 9.0\ 10^{-14}$ cm^{-2}

Gap $E_C - E_V = 1.124$ eV

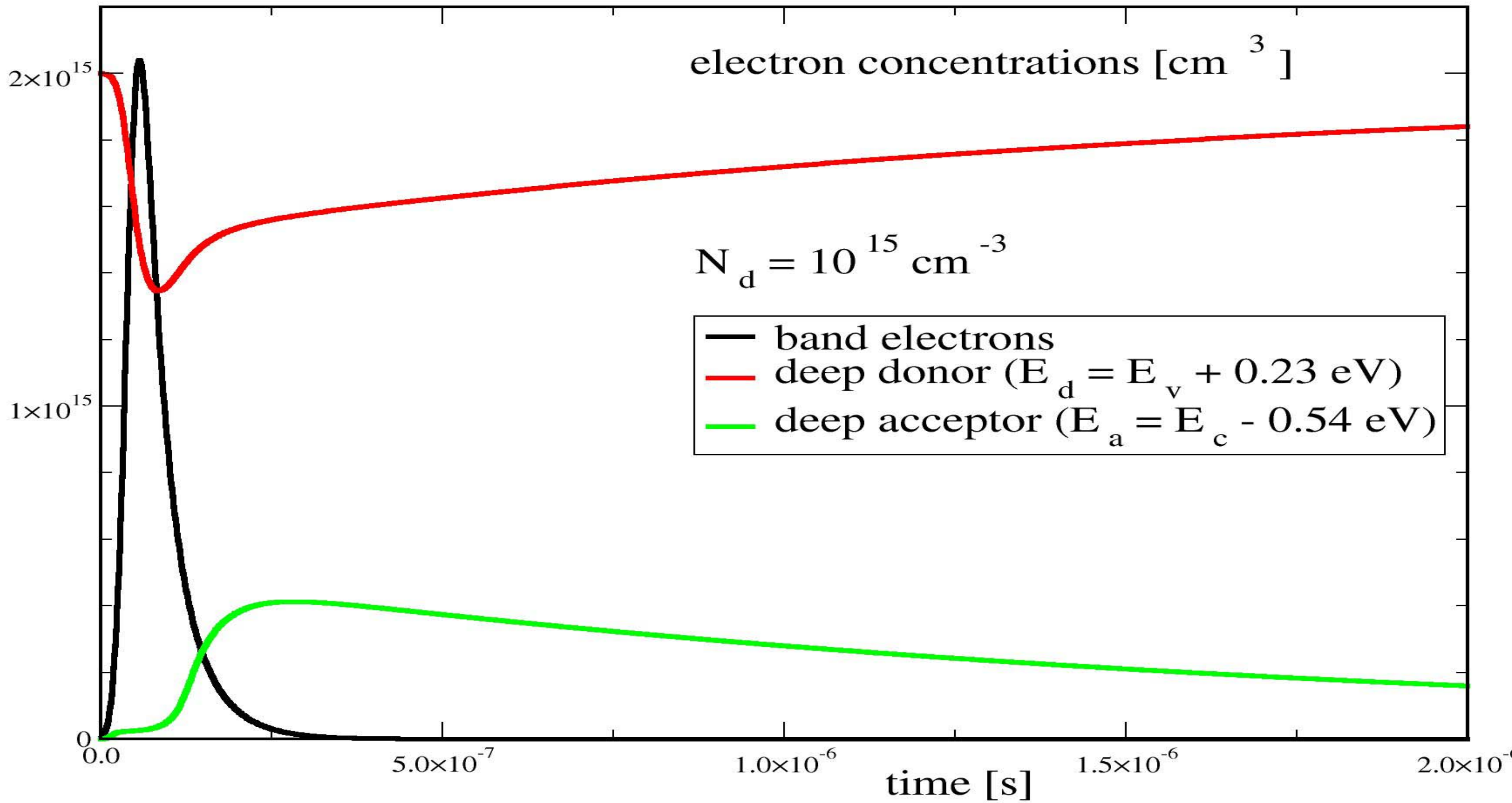
I. Pintilie *et al*, Appl. Phys. Lett. **81**, 165 (2002)

Other parameters are chosen: $N_A = 10^{15}$cm^{-3}, $\sigma_{DC} = 10^{-15}$ cm^{-2}, $\sigma_{DV} = 10^{-15}$ cm^{-2}

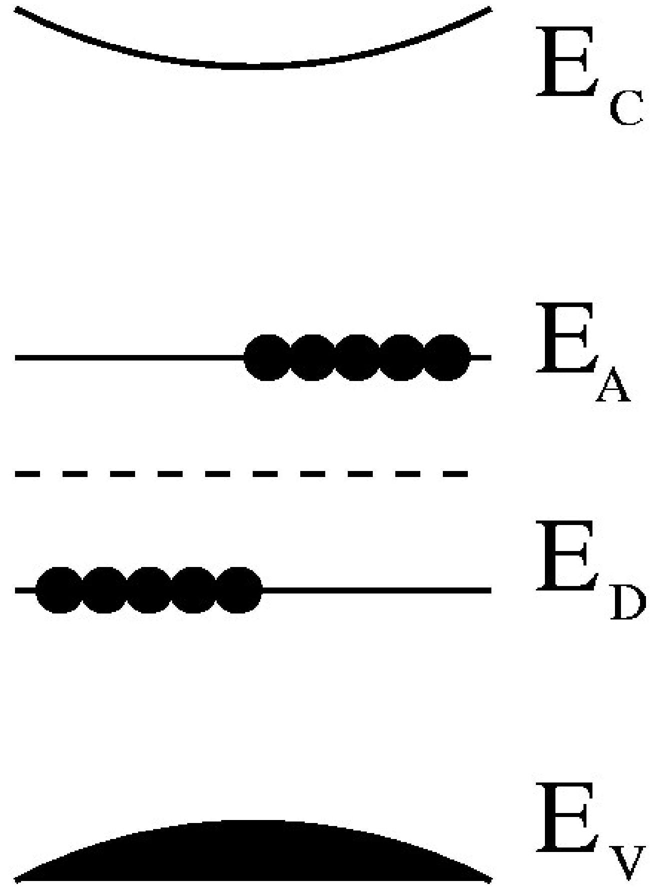
Donor concentration is variated.



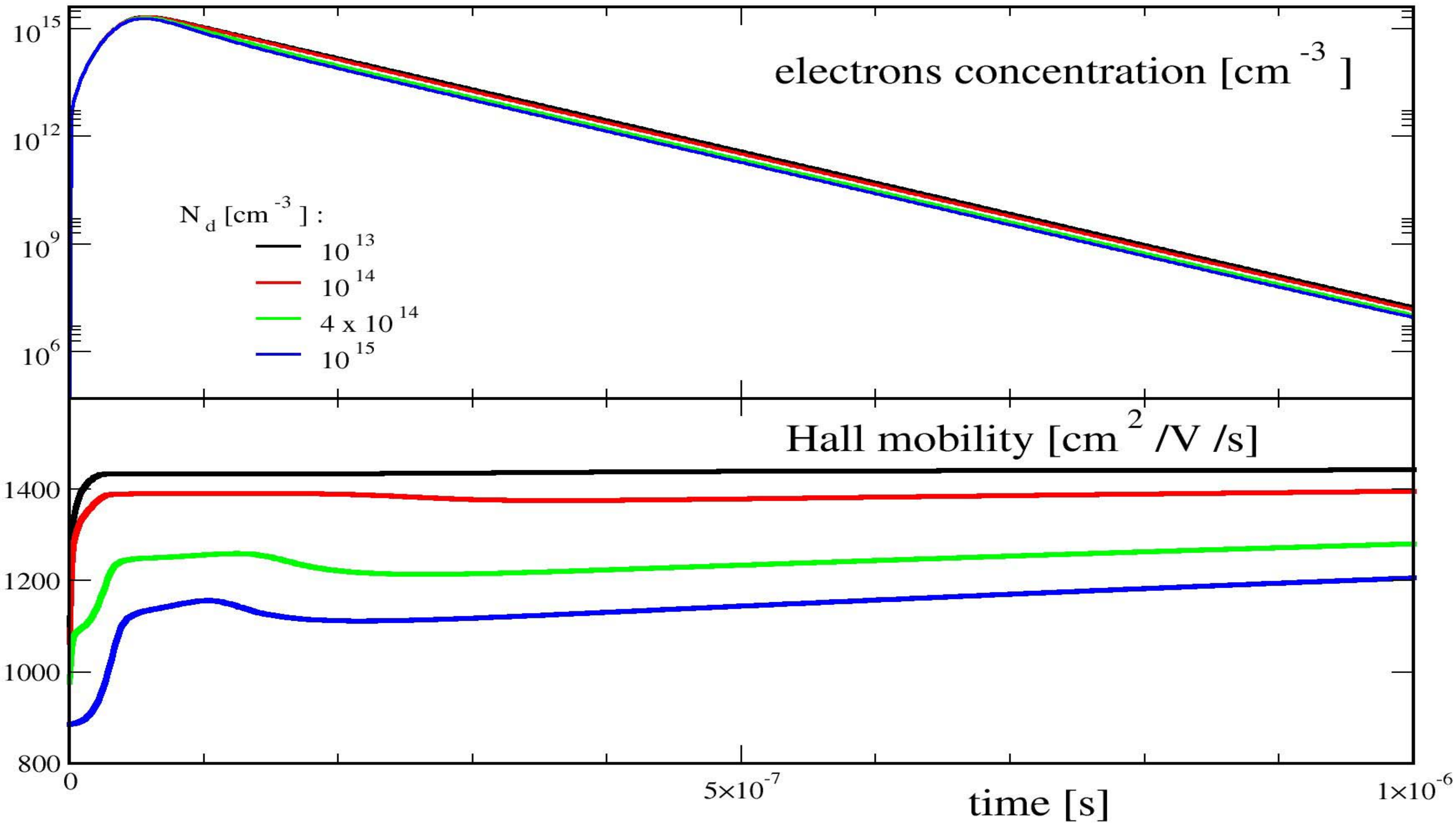
Time dependencies of electron concentration and Hall mobility. At $t = 0$ system is in thermal equilibrium and is excited by a short laser pulse. Results in both panels are shown for different donor concentrations as indicated in the legend.



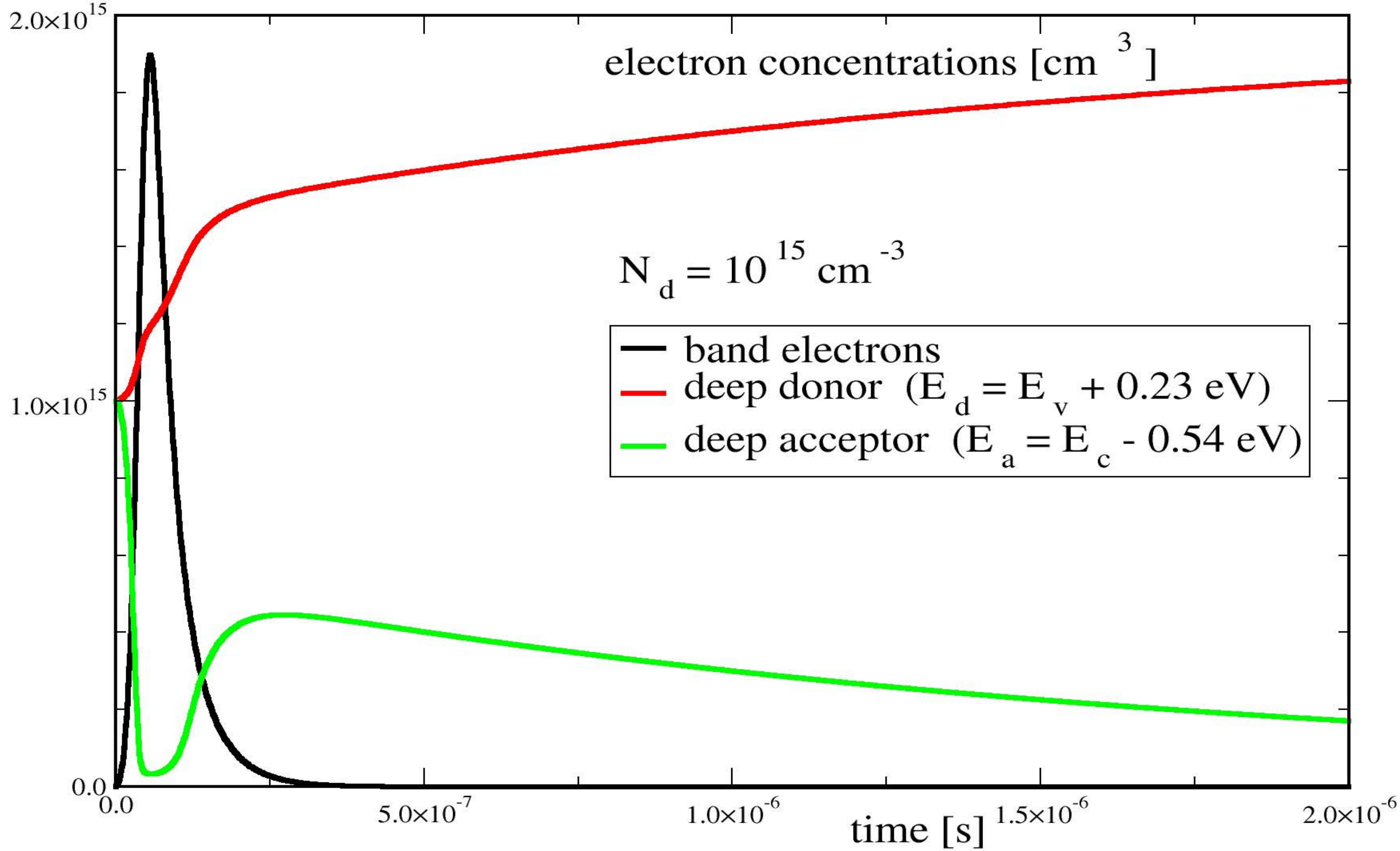
Time dependences of electron concentrations in the conduction band and in the donor and acceptor levels. At $t = 0$ the system is in thermal equillibrium. Concentrations are shown for the case $N_D = 10^{15}$ cm^3.



Metastable charged state:
donor and acceptor are ionised by a short laser pulse.



Time dependencies of electron concentration and Hall mobility. At *t = 0* system is in a metastable charged state and is excited by a short laser pulse. Results in both panels are shown for different donor concentrations as indicated in the legend.



Time dependences of electron concentrations in the conduction band and in the donor and acceptor levels. At *t = 0* the system is in a metastable charged state. Concentrations are shown for the case $N_D = 10^{15}$ cm^3.

Photo-Hall effect II

$$\frac{Y}{\Delta n} = \mu_{0H} A_s \beta v \left(2Z_0 + \frac{\Delta n}{N_s} \right) = \left(\frac{Y}{\Delta n} \right)_{t \to \infty} - \frac{\Delta n}{N_s}$$

$$Y = \mu_{0H} A_s \beta v N_s \left(2Z_0 + \frac{p_s}{N_s} \right) \frac{p_s}{N_s}$$

$$\mu_s = e \left[N_s \left(2m^* kT \right)^{1/2} S \right]^{-1}$$

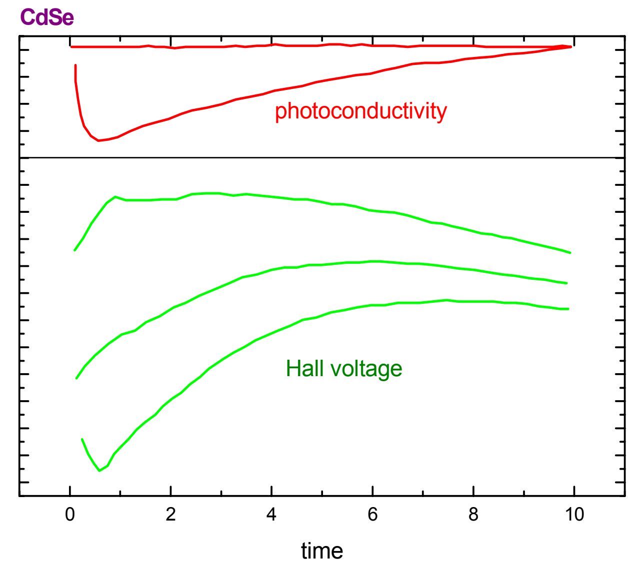
Model materials:

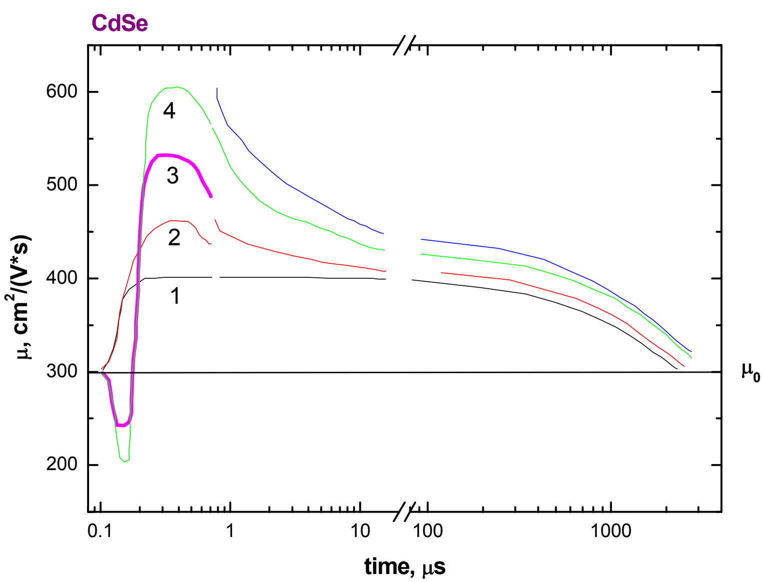
a) CdSe – point defects, point defect associations and clusters;

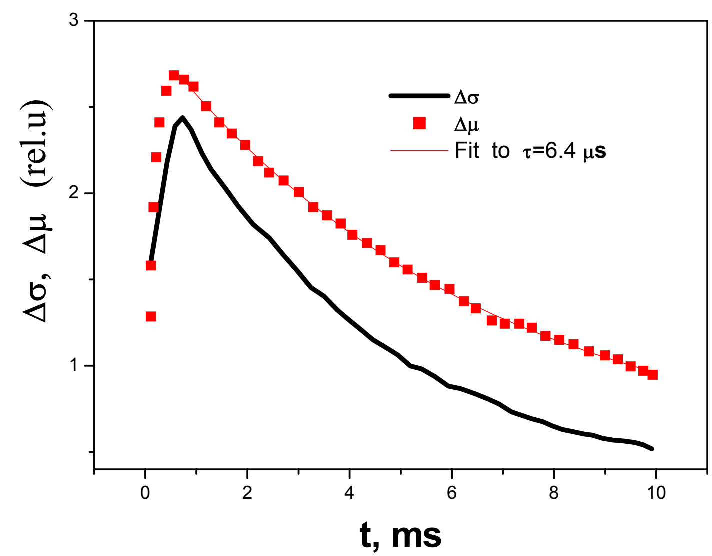
b) Ge(Cu) – multi-charge defects and clusters;

c) GaAs – point defects, EL2 modification, percolation effects.

Examples: CdSe







Conclusions:

- Recognition of point and cluster defect charge change is possible;
- More sensitive to a defect type than other methods!

- Why do not try?.

Samples: planar Hall “bars” or Van der Pauw