RD50 Common project proposal:

Mobility of carriers in irradiated Silicon

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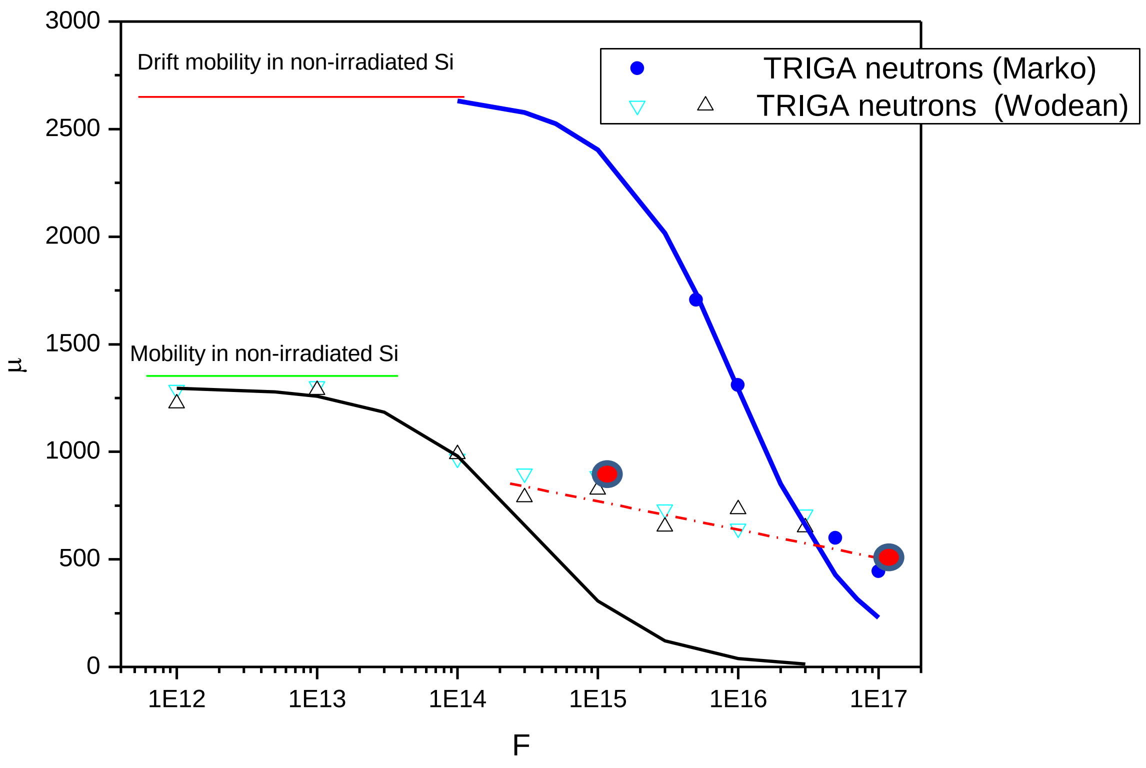
The aim of this RD50 Common Project is to create a data base about **free carrier mobility dependence on fluence and electric field in differently irradiated silicon.**

- Vilnius University team is ready to measure these dependences of mobility of carriers by magnetoresistance means in the microstrip samples.

- We also will measure the deep levels (0.5 eV and deeper) by photoconductivity spectral dependence.

The discussions on the mobility dependence on irradiation fluence have been started at 26th and 27th RD50 Workshops

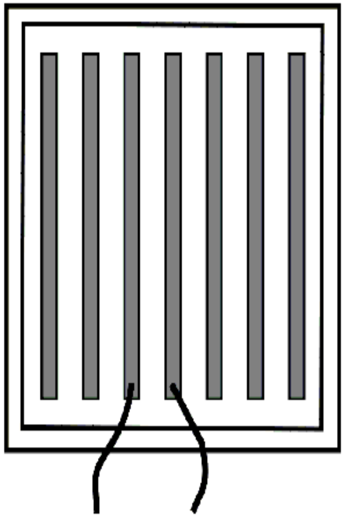


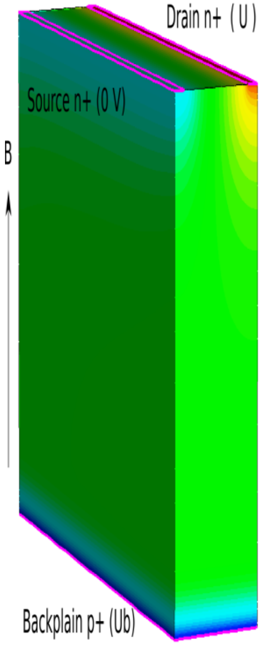
- Marko Mikuz demonstrated the indirect measurement of mobility in the highly irradiated Si, and approximated it as a square root dependence on the fluence.
- The mobility values in the samples irradiated to the fluence 1e16-1e17 cm-2 were similar to our measurements of magnetoresistance mobility in low E.
- It was decided to perform more detail measurements in the microstrip samples.

- Red dots - high E field, microstrip samples

The samples: standard microstrips, given by Ljubljana U group.

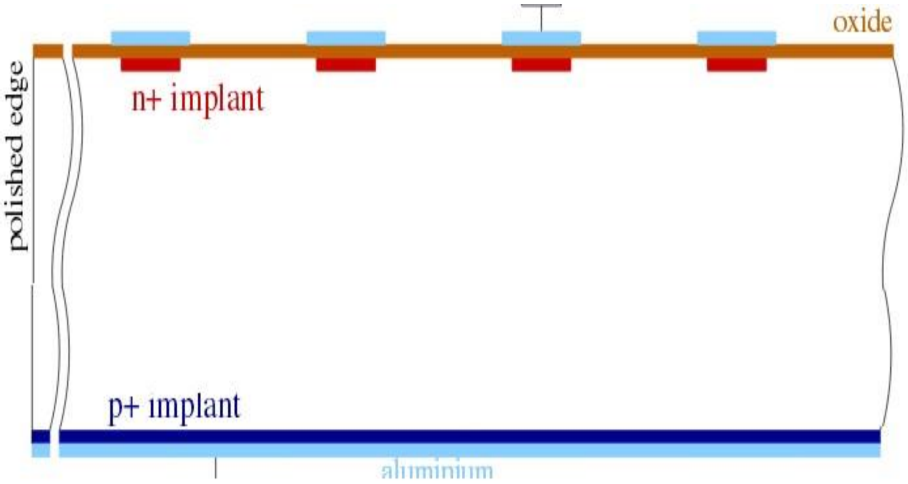
Silicon strip detectors on Float Zone (FZ) and Magnetic Czochralsky (MCz) were irradiated by fast neutrons with the fluence up to 10^{17} n/cm^2.





L/W = 0,0043, that is very near to
the Corbino dick value, and
magnetoresistanse effect will be maximal

0.00429cm

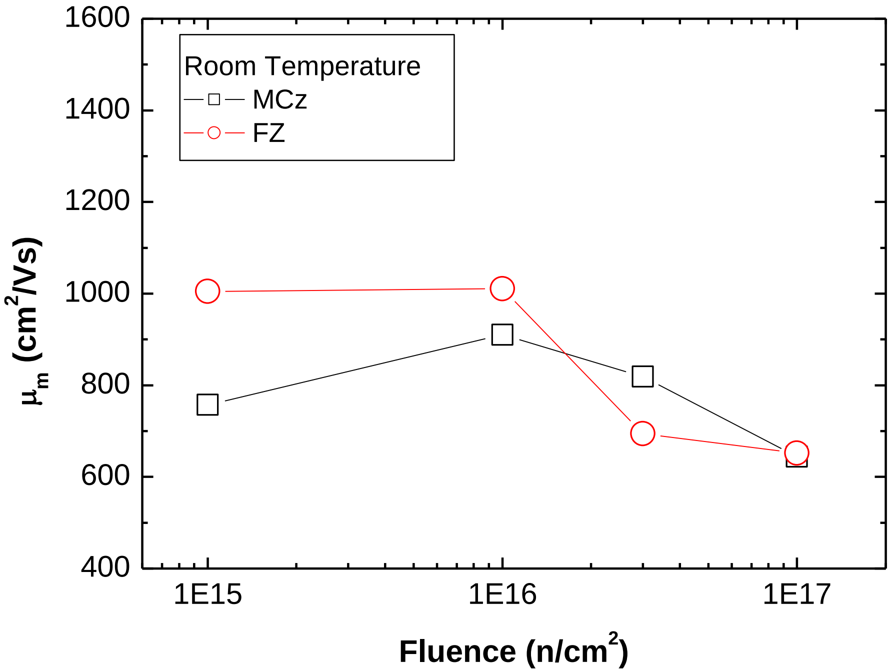


It was necessary to:

break down the oxide level;

It would be nice to remove the rear layers

Mobility dependence on neutron fluence



$1/\mu=1/\mu_{phonons} + 1/\mu_{impurities}$

$\mu_{phonons}$ +decreases with E,

$\mu_{impurities}$ increases with E,

if impurity is charged.

- Samples were irradiated in TRIGA reactor

We are ready to measure magnetoresistance mobility and it temperature dependence in the microstrip samples.

- We ask the partners to find in your boxes or frigs the differently irradiated Si microstrip structures.
  - It would be better :
    - if the DC coupling would be possible;
    - If the rear structure would be removed to have only the Si with microstrip contacts. This structure correspond the requirements for the magnetoresistance measurements.

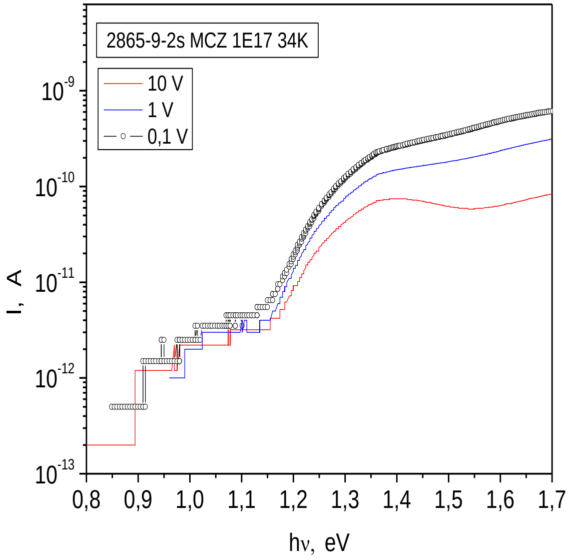
- Therefore the partners contribution:
  - 1. A time to find the samples;
  - 2. To realize DC coupling (if microstrip with AC coupling we used a breakdown at forward direction microstrip-pad.)
  - 3. The cost of etching of the back contact.
  - (Maybe there is a laboratory which could etch all samples?)

Additional possibilities:

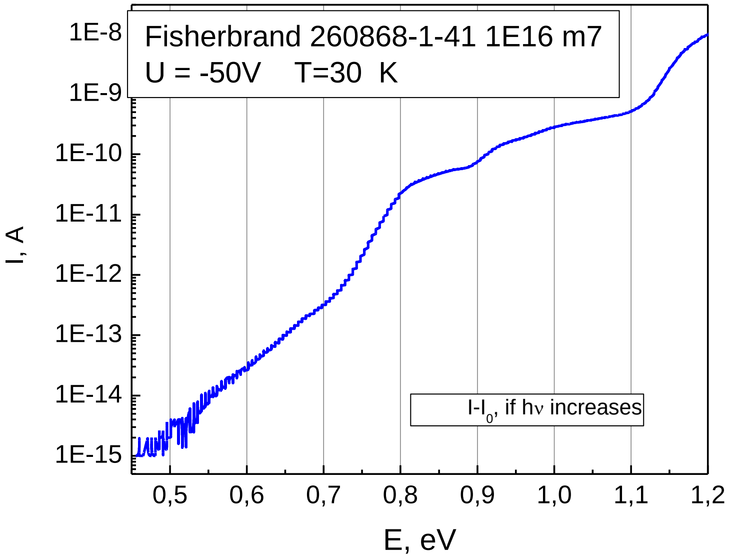
- As there is an interest to understand the influence of a charge in SiO2 layer, it is possible to introduce or remove charge in it by electrostatic charging (and measure the magnetoresistance effect).

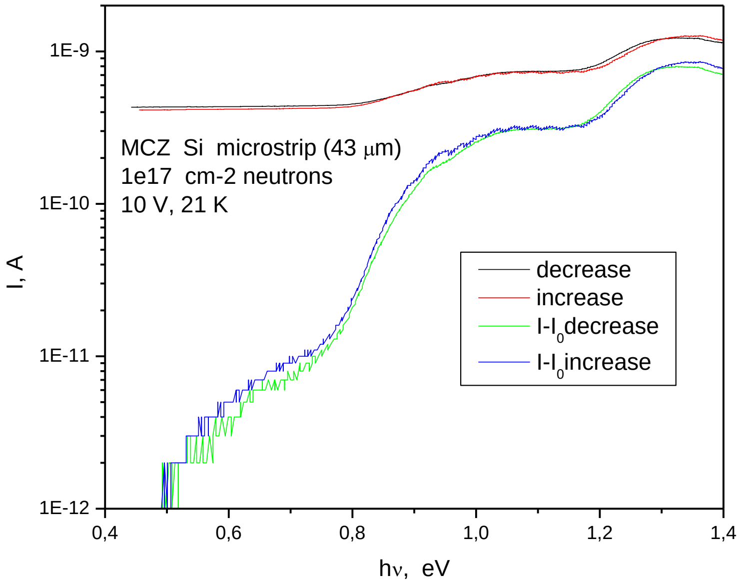
- The charge in SiO2 layer influence can be controlled by photoconductivity by PC spectrum.

The deep level energy can be determined by PC spectra in the impurity region.

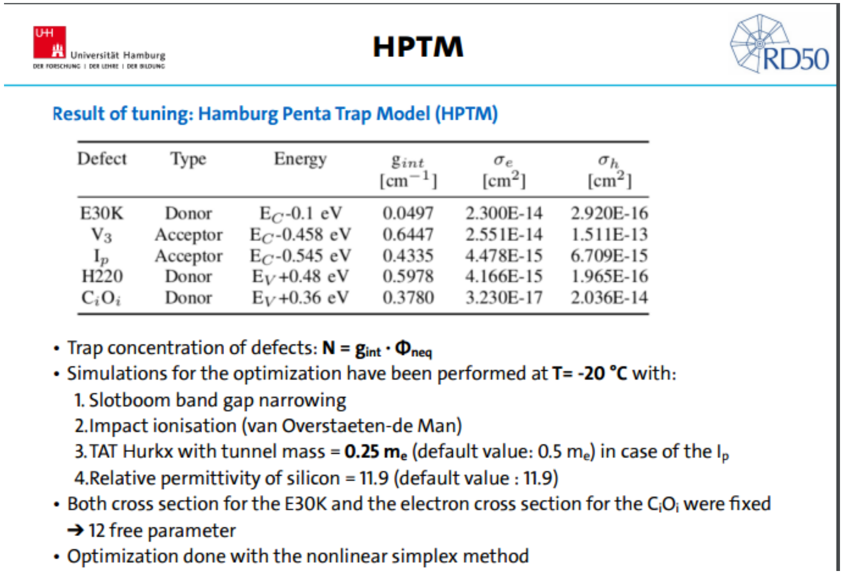


Additional option: deep level energies by PC spectra





- Ec-0.458
- Ec-0.545
- Ev+0.48=1.17-0.48=Ec-0.69
- Ev+0.36=1.17-0.36=Ec-0.81
- Ec-0.1=Ev+1,05, absent at T=30K, appears at T>120 K



HPTM

Result of tuning: Hamburg Penta Trap Model (HPTM)

Defect	Type	Energy	g_{int} [cm^{-1}]	σ_e [cm^2]	σ_h [cm^2]
E30K	Donor	E_C-0.1 eV	0.0497	2.300E-14	2.920E-16
V_3	Acceptor	E_C-0.458 eV	0.6447	2.551E-14	1.511E-13
I_p	Acceptor	E_C-0.545 eV	0.4335	4.478E-15	6.709E-15
H220	Donor	E_V+0.48 eV	0.5978	4.166E-15	1.965E-16
C_iO_i	Donor	E_V+0.36 eV	0.3780	3.230E-17	2.036E-14

- Trap concentration of defects: **N = g_{int} · Φ_{neq}**
- Simulations for the optimization have been performed at **T= -20 °C** with:
  1. Slotboom band gap narrowing
  2. Impact ionisation (van Overstaeten-de Man)
  3. TAT Hurkx with tunnel mass = **0.25 m_e** (default value: 0.5 m_e) in case of the I_p
  4. Relative permittivity of silicon = 11.9 (default value : 11.9)
- Both cross section for the E30K and the electron cross section for the C_iO_i were fixed
  ➔ 12 free parameter
- Optimization done with the nonlinear simplex method

Conclussion

- As there was demonstrated it exist a few possibilities to measure or evaluate the mobility, I invite all to join this common project to perform the systematic analysis.

Acknowledgements

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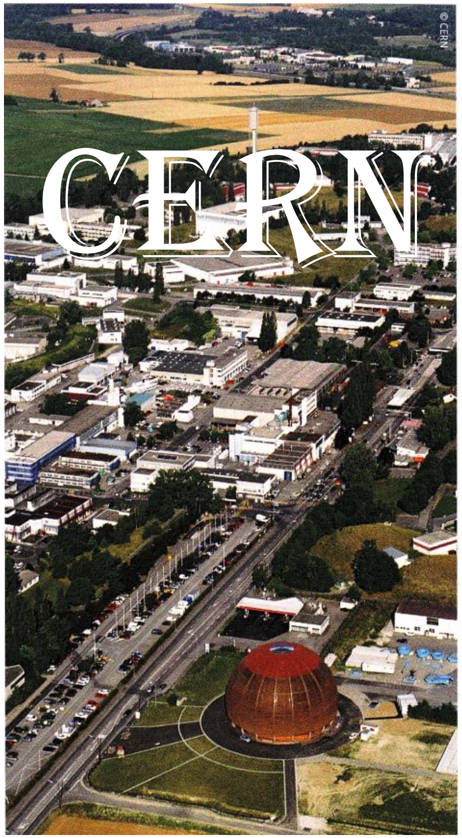
to Institute for Photonics and Nanotechnology (VU) for the partial support

and

to AIDA Transnational Access for irradiations in Triga reactor (Ljubljana)

THANK YOU

FOR YOUR ATTENTION!



Mobility dependence on sample bias, average E, V/cm