Photoconductivity and magnetoresistance mobility in the irradiated to 10^{15}-10^{17} cm^{-2} neutron fluence Si

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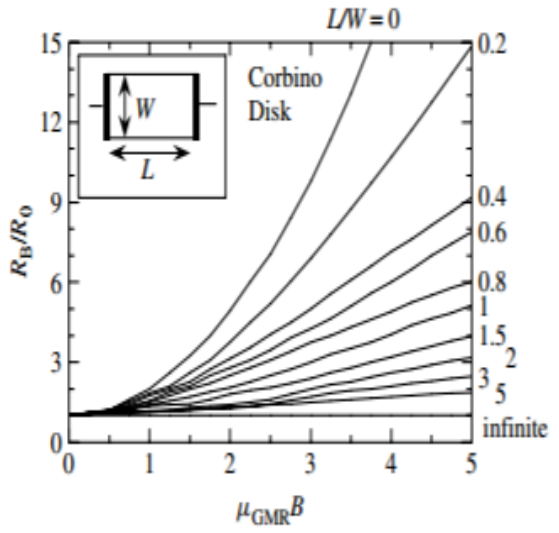
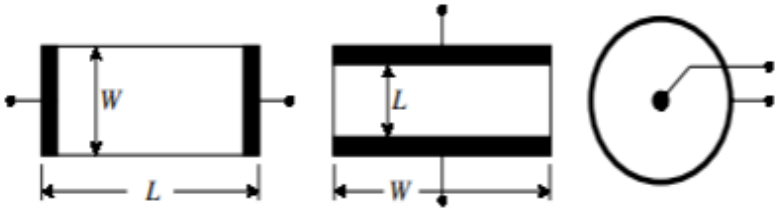
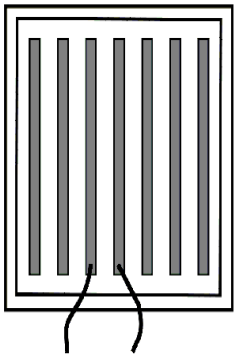
Magnetoresistance mobility

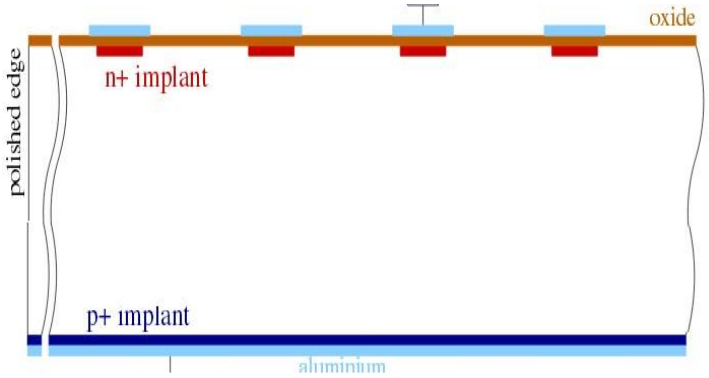
$$\mu_H = r\mu_n \qquad \mu_M = \mu_{GMR} \approx \frac{1}{B}\sqrt{\frac{R_B}{R_0} - 1}$$

$$r = \langle\tau^2\rangle/\langle\tau\rangle^2 \qquad \mu_{GMR} = \xi\mu_H \qquad \xi = (\langle\tau^3\rangle\langle\tau\rangle/\langle\tau^2\rangle^2)^2 \cong 1{,}0$$









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

The samples:

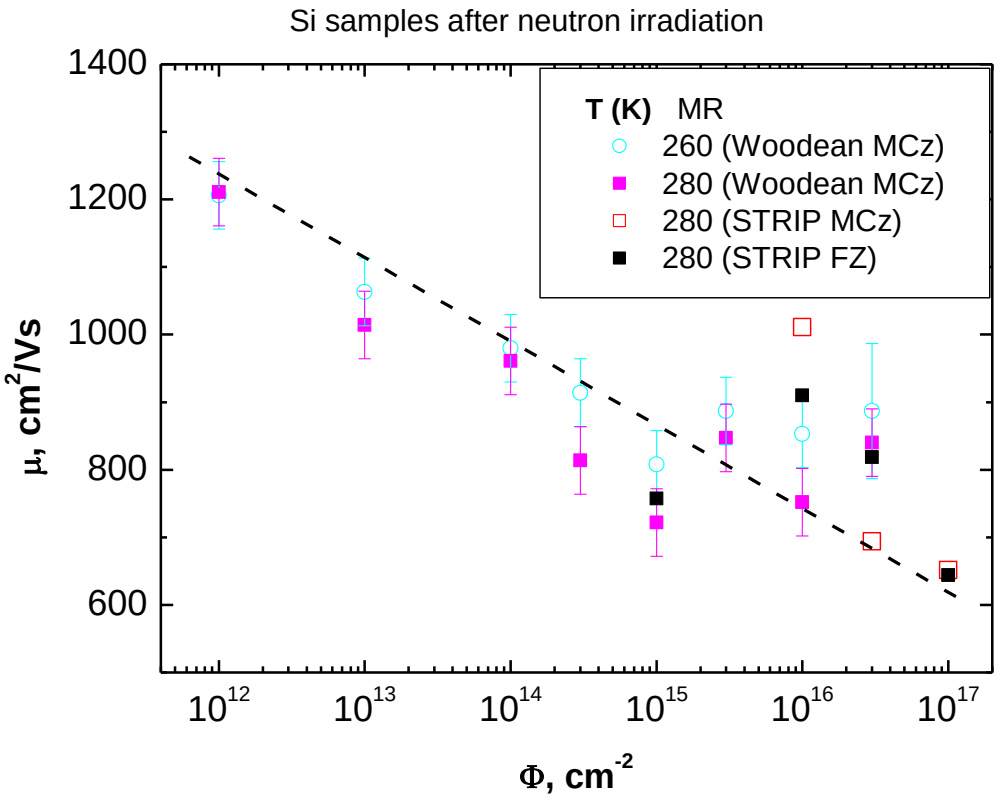
WODEAN Hall strips and the standard microstrips. irradiated in TRIGA reactor (Ljubljana).

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

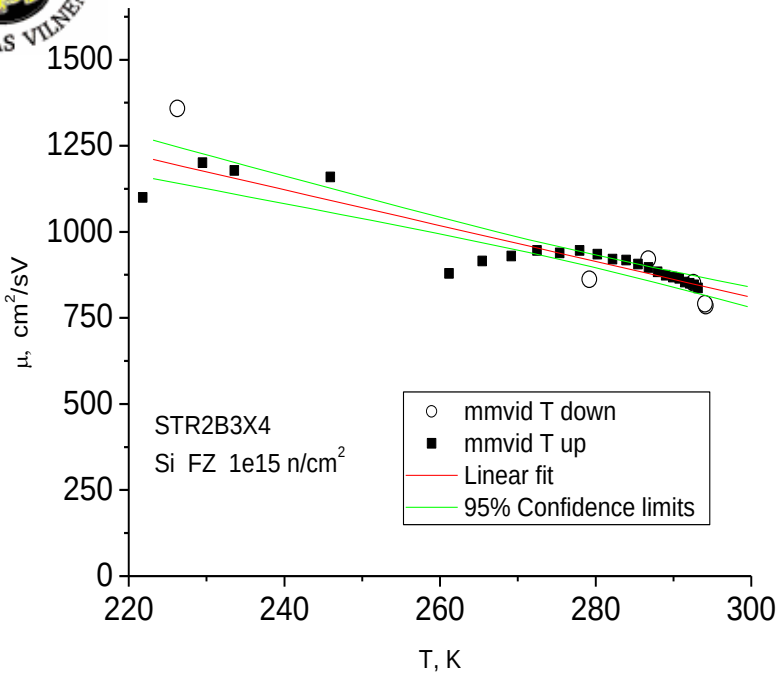
Both type samples

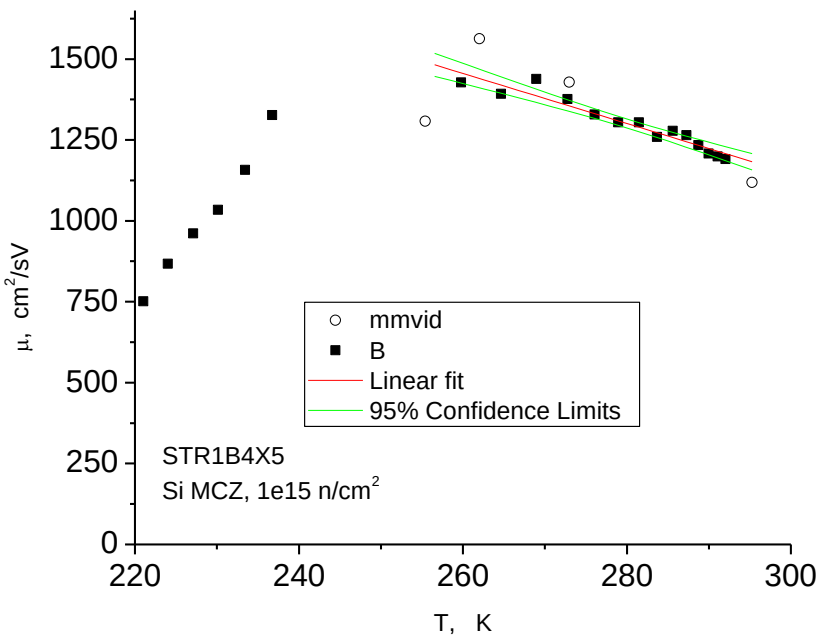
Wodean – low bias

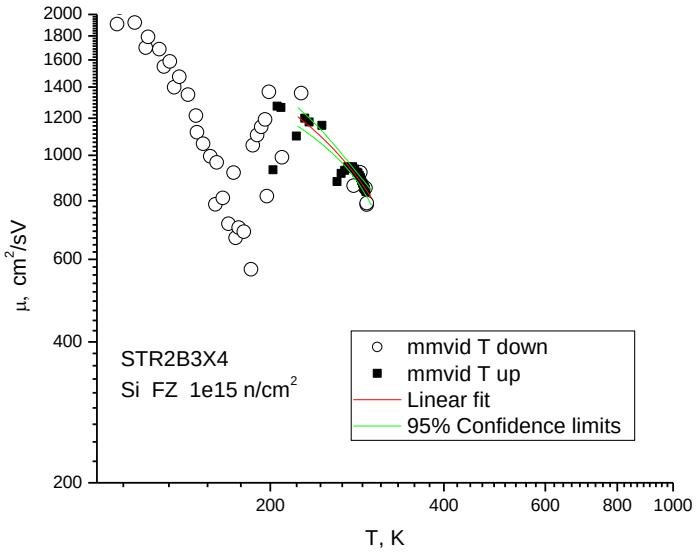
Microstrip – high bias

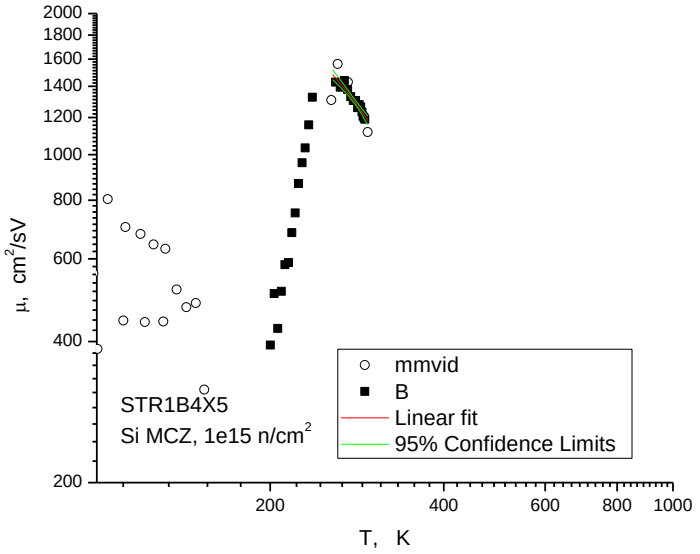


More details about mobility in microstrip Si samples

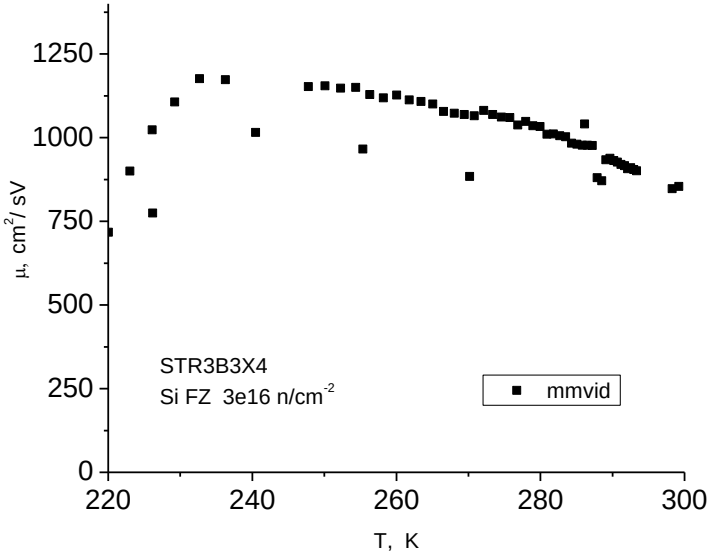


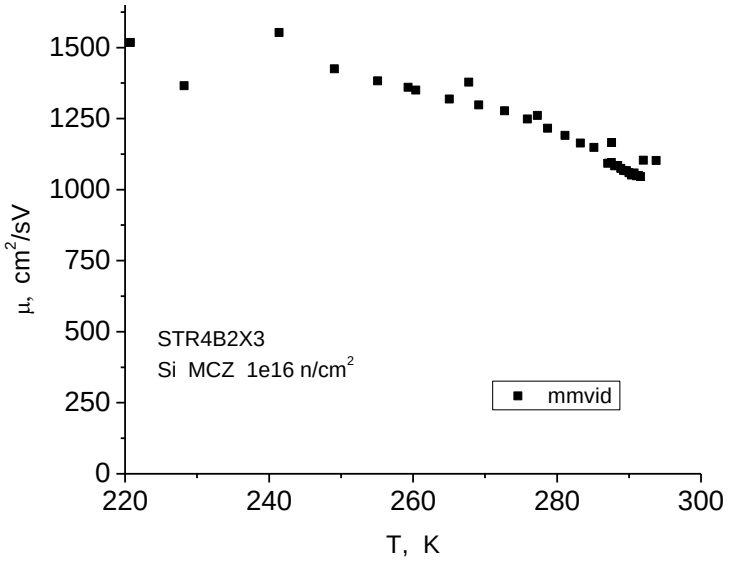


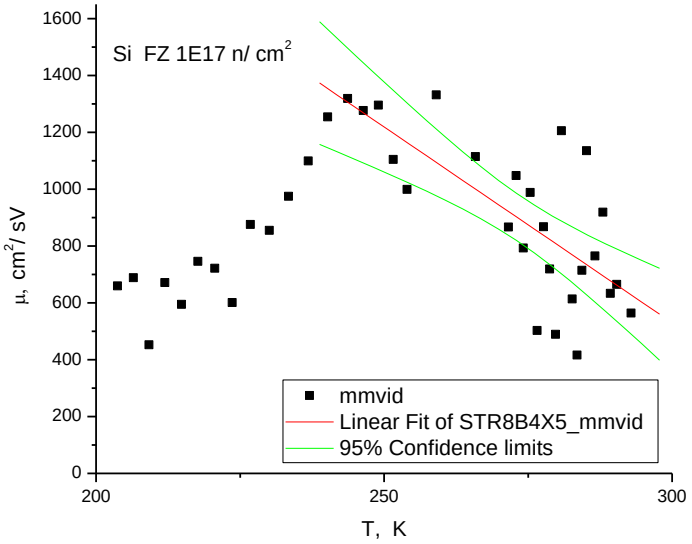




3e16 cm-2 and 1e17 cm-2





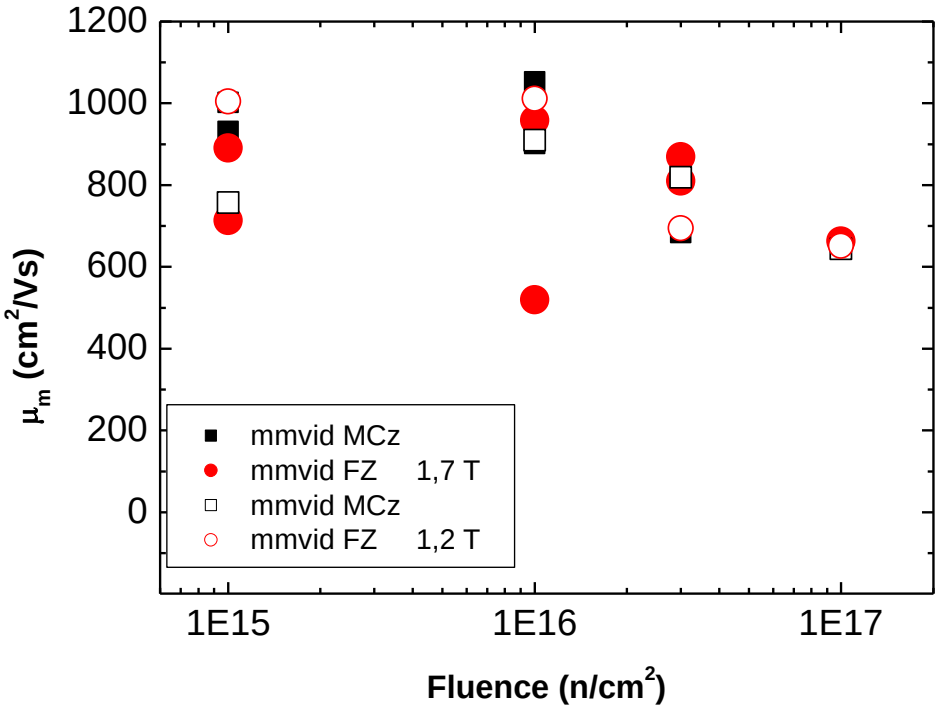


Conclusion 1:

A linear decrease of mobility on temperature proves the main free carrier scattering mechanism is related to clusters.

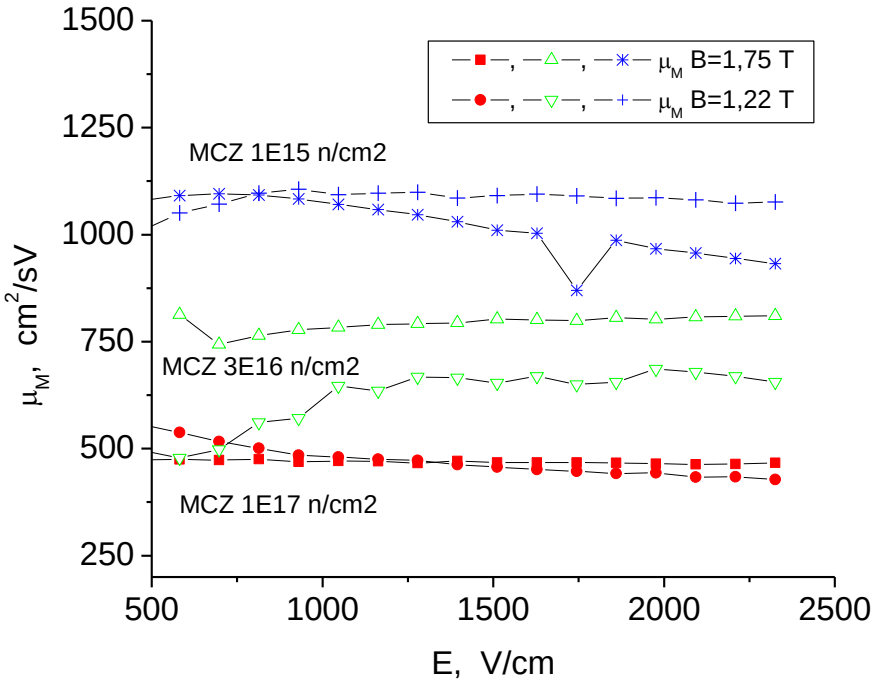
Summary of microstrip results

$$1/\mu = 1/\mu_{phonons} + 1/\mu_{point\ defects} + 1/\mu_{clusters}$$
$$= 1/\mu_{phonons} + 1/\mu_{defects}$$



- Mobility decrease with fluence
- We need more samples to get better statistics

Mobility dependence on bias



Mobility near to constant in high bias region

Conclusion:

scattering on phonons increases with bias, but on charged defects it decreases.

A result: nearly independent mobility on electric field.

Dark conductivity's (carrier concentration thermal activation rate) activation energy shows a shallowest filled local level:

$$\Delta E_{Thermal}$$

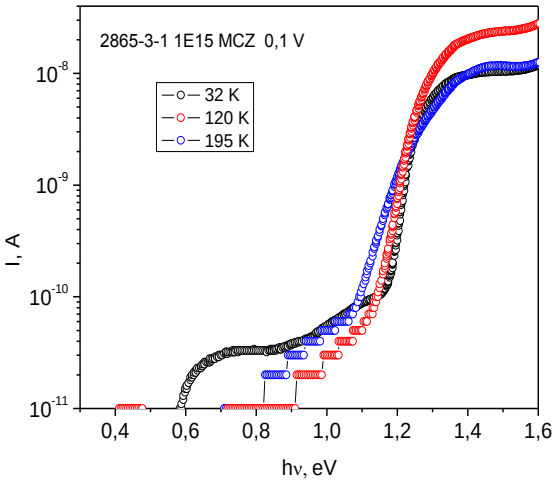
[$N_c(T) \sim T^{3/2}$, $\mu(T) \sim T^{-1}$, if T=260-300 K in irradiated Si]

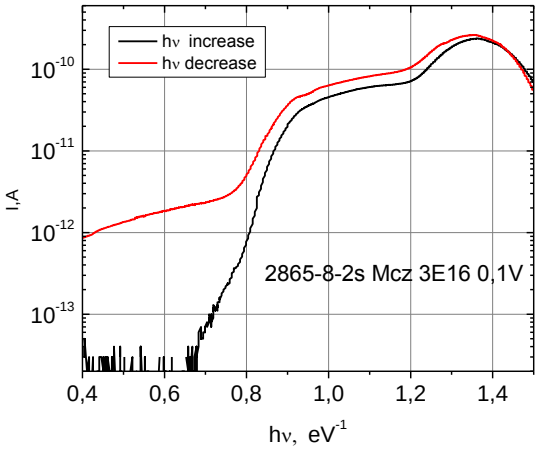
Extrinsic photoconductivity spectra structure show the levels that are filled or the levels that participate in the two step (thermal and optical) excitation process.

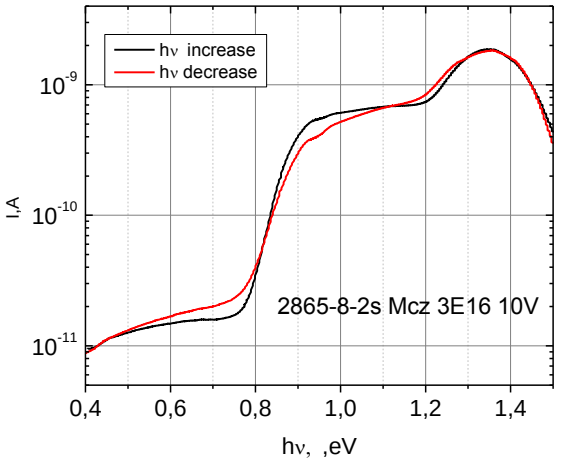
$$\Delta E_{Optical}$$

$\Delta E_{Optical}$ and $\Delta E_{Thermal}$ difference depends on the electro-phonon interaction in the defect

Photoconductivity spectra

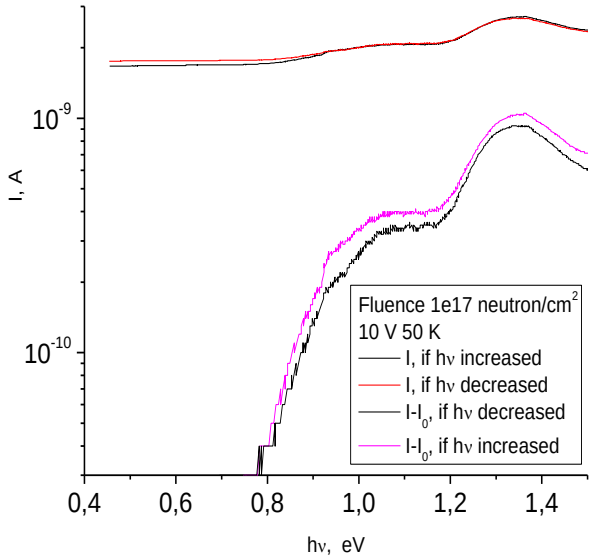


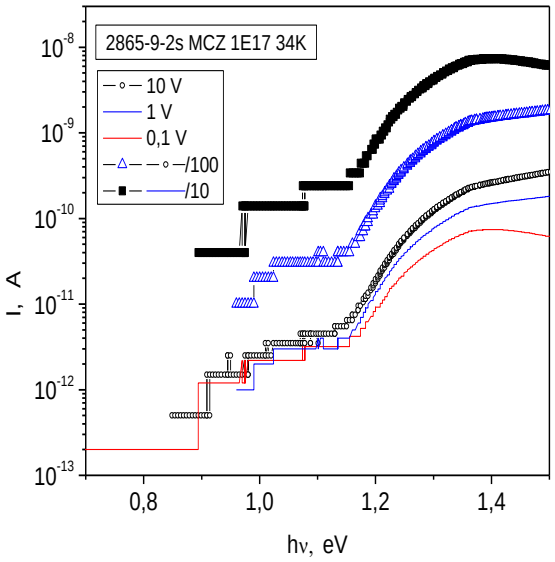


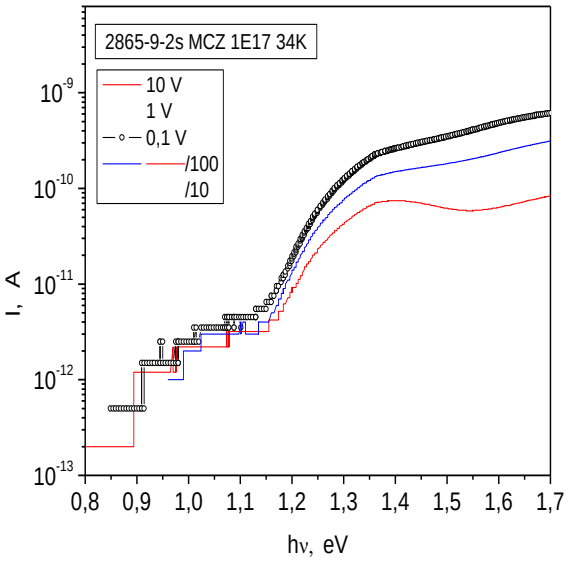


- At low T and low bias the recombination centres (0,8 eV) and traps (0,3, ..., 0,6 eV) observed
- At “high” T and at high bias only recombination centers are seen.

Photoconductivity spectra







- At “high” T and at high bias only recombination centers are seen.

- High bias increased the surface recombination velocity in the micro-strip sample.
- The impact ionization was observed in the highly irradiated Si.

Summary of dark and photo conductivity

The main center in Si irradiated to 1e17 neutrons/cm^2

- Bias 23 V/cm, $\Delta E_{Thermal}$=0,541; ΔE_{Optic}=0,8 eV
- Bias 2320 V/cm, $\Delta E_{Thermal}$=0,504; ΔE_{Optic}=0,8 eV

Frank-Condon shift - 0,22÷0,3 eV

Conclusions 3:

- Dependence of $\Delta E_{Thermal}$ on bias confirms model of existence of micro-inhomogeneities in the irradiated Si.
- Disappearance of photoresponse from the levels more shallow than 0,8 eV at high bias proposes the emptying of levels by electric field.
- Increase photoresponse, if $h\upsilon$ > 1,3 eV, directs to an existence of extrinsic impact ionization.

Acknowledgements

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THANK YOU

FOR YOUR ATTENTION!