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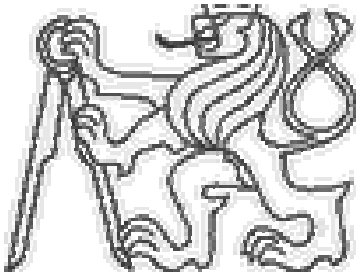

Intentionaly Partly Damaged Si Radiation Detectors

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Motivation

The main aim of this work was to measure the spectroscopic response of intentionally damaged MESA silicon detectors.

The measured spectroscopic responses of the irradiated detectors were compared to the response of the undamaged detector

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Experiment arrangement

A uniformly damaged region was created using protons delivered by the Montreal University 6 MV tandem accelerator at different energies and fluences.

Only the back half of the detectors was damaged.

The vacancy density created in the damaged region was built at a level of 7x 10^{15} vacancies/cm^3.The detectors were scanned over their whole volume with protons of well defined ranges. The response characteristics were studied using protons backscattered from a thin gold foil at 8 different primary proton beam energies.

Experiment arrangement

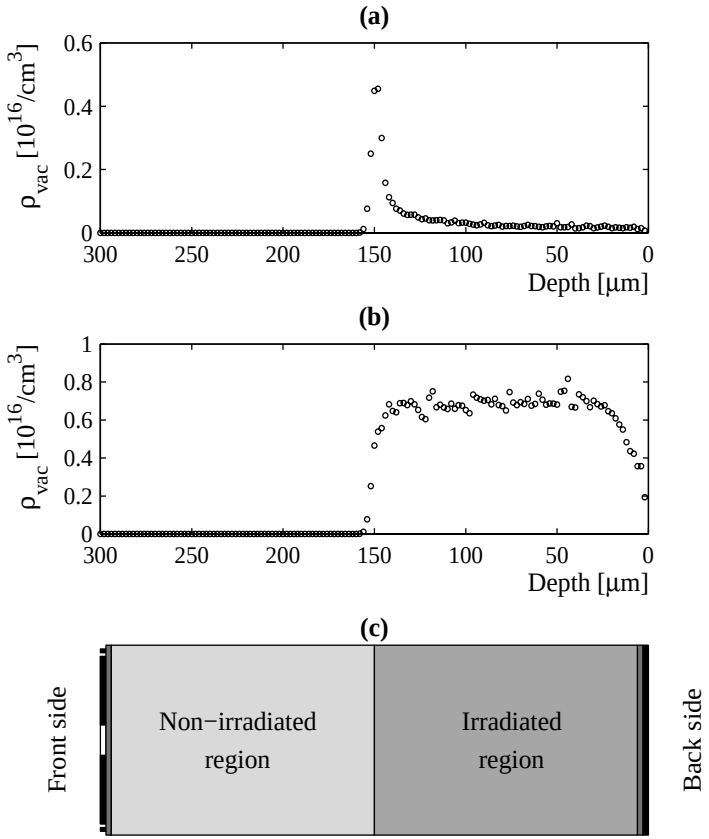


Fig.1: a,b- vacancy density after irradiation, c- detector visualisation

Spectroscopy

The scanning of the detectors from the undamaged front side was performed with three different proton energies of ranges within the undamaged region.
Two proton energies were selected for probing the transient region extending between the damaged and undamaged regions of the detectors.
Three energies of protons were chosen to probe the damaged region of the diodes.
The same set of energies was selected for the study of the detectors spectroscopic features while illuminating the detectors back side.

Spectroscopy

A non-irradiated and intentionally back side damaged MESA detectors were both scanned by illumination of their front and back side at 8 different incident proton beam energies The protons used for the scanning were obtained by Rutherford backscattering of primary proton beam from a very thin gold foil to bring the flux of protons to a spectroscopically countable rate. The highest illumination energy was 6.28 MeV corresponding to a range for which the protons are essentially stopped in the n+ back side electrode region.

Spectroscopy

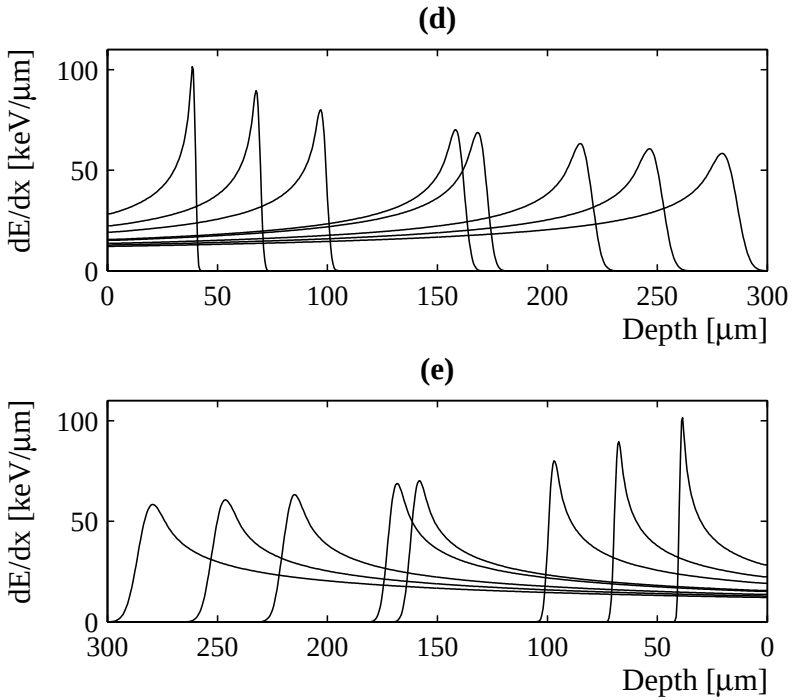


Fig.2: The Bragg curves of probe protons with 8 used energies

Results

The detector behavior is strongly different if irradiated from front side or from back side.

Irradiation from front side is fatal. It destroys the surface structures (as the guard rings) and leads to increase of leakage current to non-acceptable values. Together with it the TCCE deteriorated as well.

If irradiated from back side, the detector damage seems to be non fatal, the “front half of detector” works normally (with acceptable leakage current and CCE near 100%) and the “damage of back area” results only in the decrease of CCE.

Results

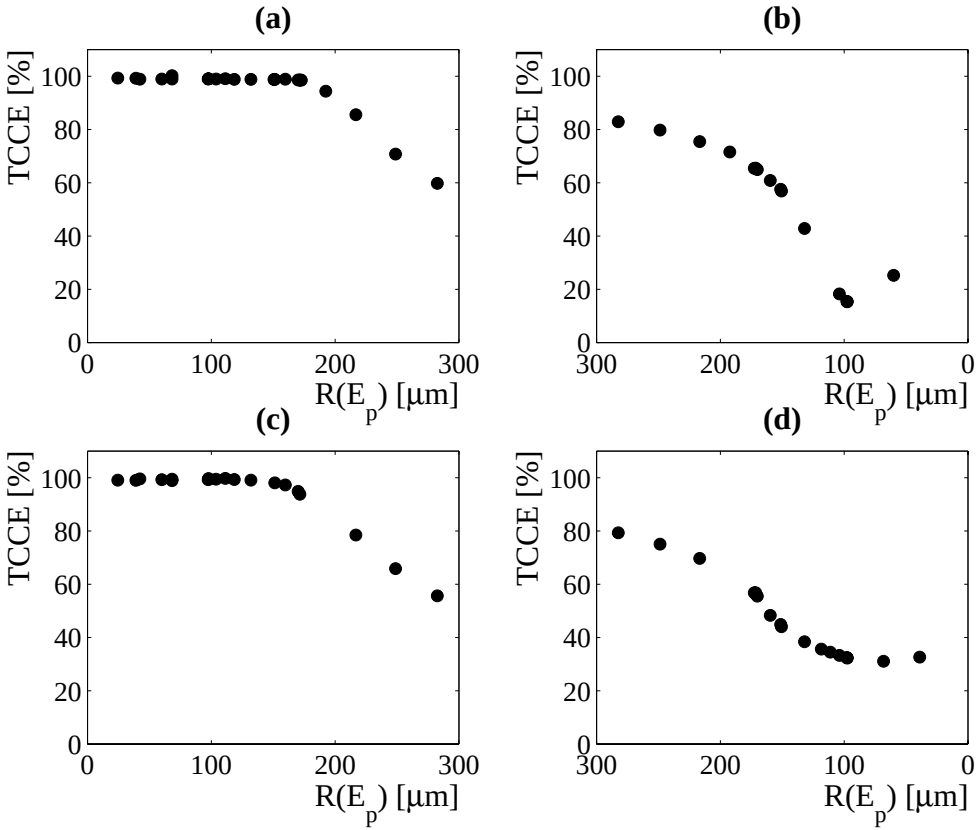


Fig.3: Dependence of the Total Charge Collection Efficiency on the position in the damage/undamaged region of the detector (a,c scanning from front side, b.d from back)

Results

In addition to the spectroscopic studies, the I-V and DLTS study has been performed

I-V curves has been at back side irradiated detectors practically unchanged whereas in case of front side irradiation the leakage currents have been strongly increased

DLTS study has not been unfortunately successfully carried out for more problems

Conclusions

A nearly uniformly damaged region was created in about 300 μm thick MESA planar silicon radiation detectors using protons at different energies and fluences. The damaged region, corresponding to a vacancy density of $7x10^{15}$ vacancies/cm^3, was extending over a depth of 150 μm from the back side of the detector.
The sensitive volume of the MESA-planar silicon diodes was scanned with protons of well defined energy and range. The measured spectroscopic responses for non-irradiated and irradiated detectors were compared.

Conclusions

If illuminated from front side, the TCCE was determined close to 100% for protons stopped in the undamaged region and decreased to a relative value of 50% for protons stopped in the damaged region.

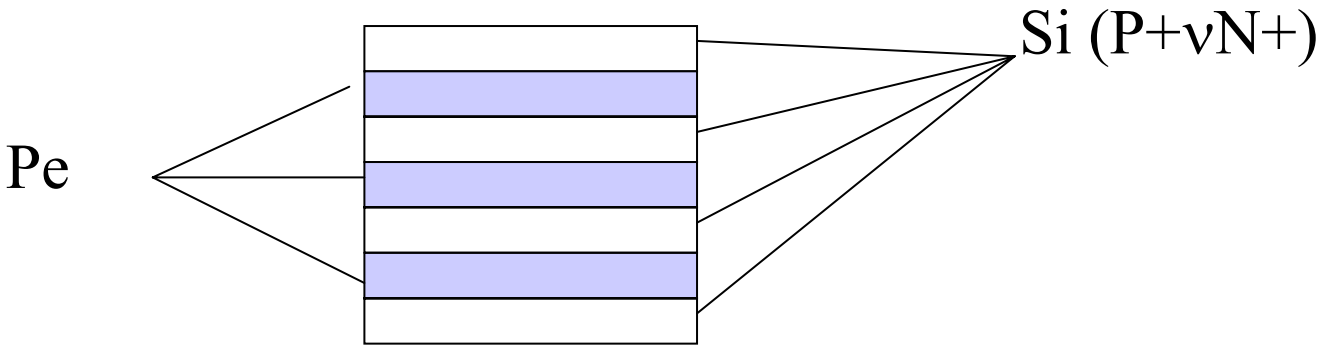
In the case of back-side illumination of the damaged detector, the TCCE was significantly smaller for protons of low energy, about 15% and 30% at a depth of 100 μm for the detectors No.~22 and 45, respectively. The TCCE increases up to 80-85% for the highest proton energy stopped in the detector.

Conclusions

The present experimental results show that the silicon MESA planar detectors can already be partly and strongly deteriorated by MeV protons of fluences at the level of 10^{11} p/cm^2

Further plans

During October 2004 will be Si detectors irradiated by neutrons in Czech Nuclear Research Institute in following configuration:



Pe (Polyethylene – containing -CH) will serve as proton converter, energies of neutrons will be in the range of 5-15 MeV (fast neutrons)

Further plans

In this study we expect to compare the properties of uniformly irradiated detectors (previous study) with the properties if irradiated by recoiled protons from Pe layers

A complete DLTS study of detectors irradiated at various fluences will be performed

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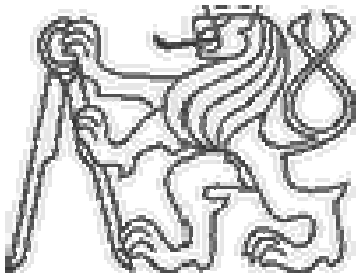

Thank you for your attention