An increase of the quantum yield in highly irradiated Si.

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Instead of outline:

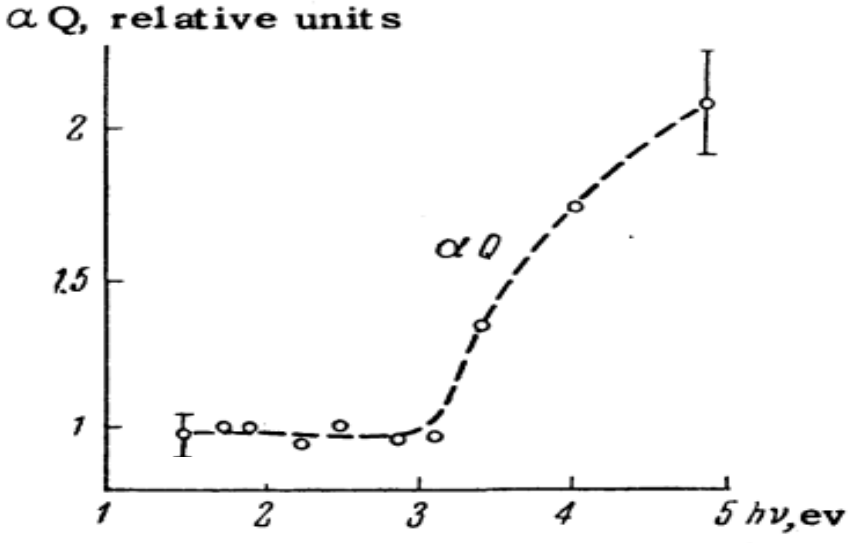
- The measurement of spectral dependence of photoconductivity permits to investigate:
  - the deep level spectrum,
  - recombination at the surface,
  - photoelectric quantum yield.

- This presentation deals with observation of an increase of quantum yield at lover photon energy in highly irradiated Si in comparison with less or non-irradiated Si.

Impact ionization is the inverse Auger recombination.

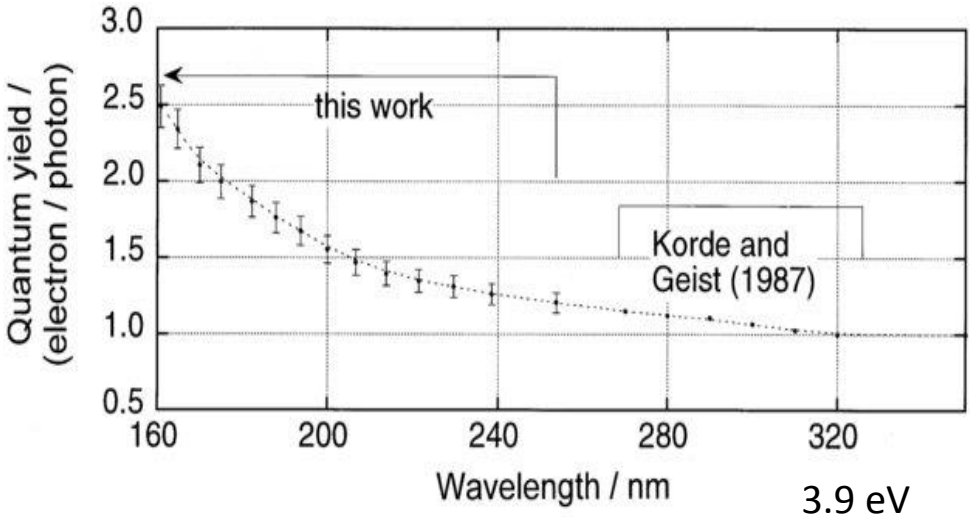
An electron relaxes to an energetically lower state inducing the excitation of a valence band electron into the conduction band.

These relaxation channels follow restrictions imposed by energy and momentum conservation.



A considerable rise in the aQ vs. hν curve is seen, starting with approximately hν = 3.25 ev.

QUANTUM YIELD OF PHOTOIONIZATION IN SILICON V. S. VAVILOV and K. I. BRITSYN (1958) J. Exptl. Theoret. Phys. (U.S.S.R.) 34, 1354.

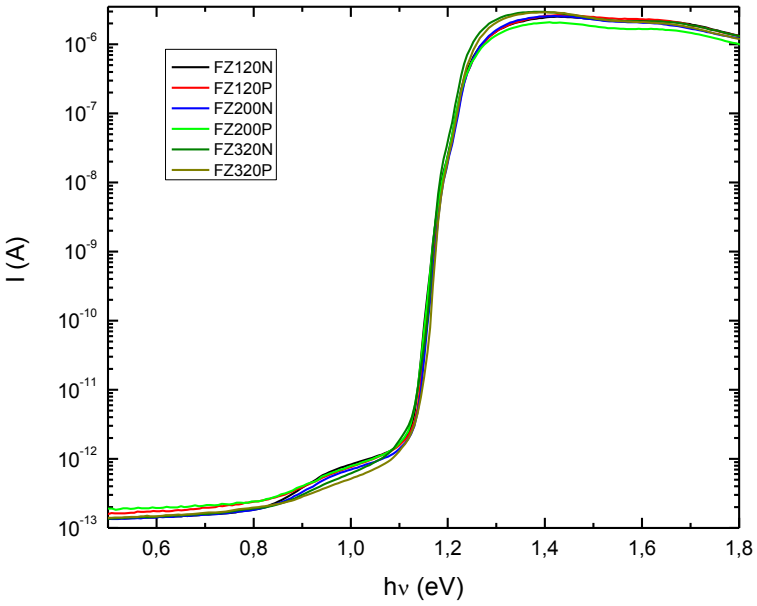


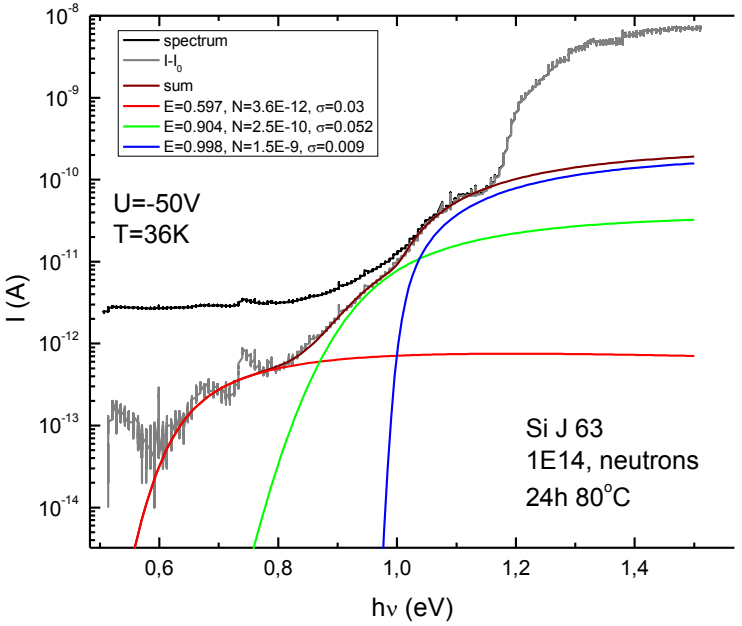
3.9 eV

The quantum yield of silicon from 160 nm to 254 nm.R Canfield, R.E Vest, R.Korde et al. Absolute silicon photodiodes for 160 nm to 254 nm photons. (2003) Metrologia 35(4):329

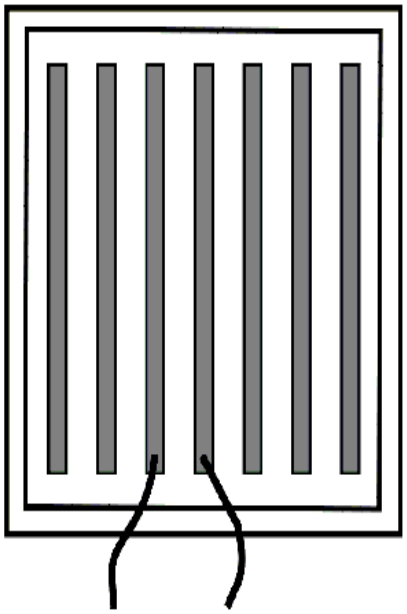
Non-irradiated and a low neutron fluence Si.

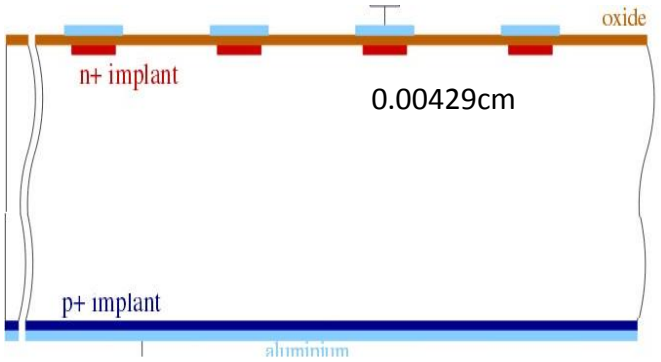
There are seen: the deep impurities and a small recombination at the surface velocity.

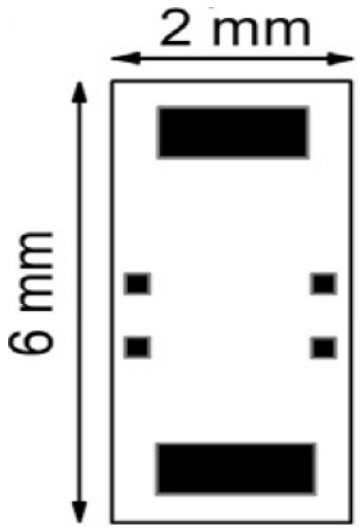




The samples: standard microstrips and rod type.
Silicon (FZ) and (MCz) and were irradiated by fast neutrons with the fluence up to 10^{17} n/cm^2 in TRIGA reactor, Ljubljana.

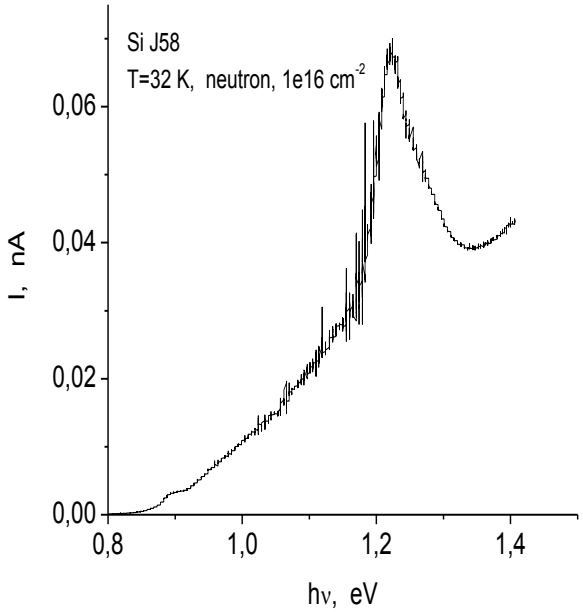






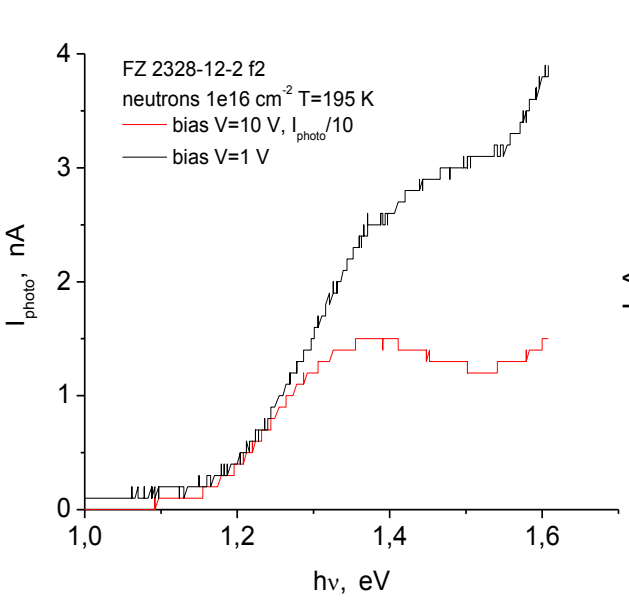
Fluence 1-2 10^{16}cm^{-2}

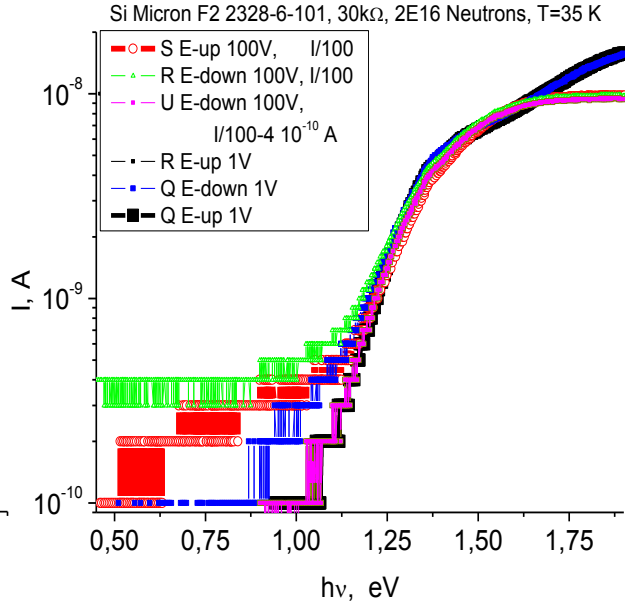
Rod-type sample



The surface recombination velocity is high in rod-type sample but an increase of photo response relates to increase of quantum yield.

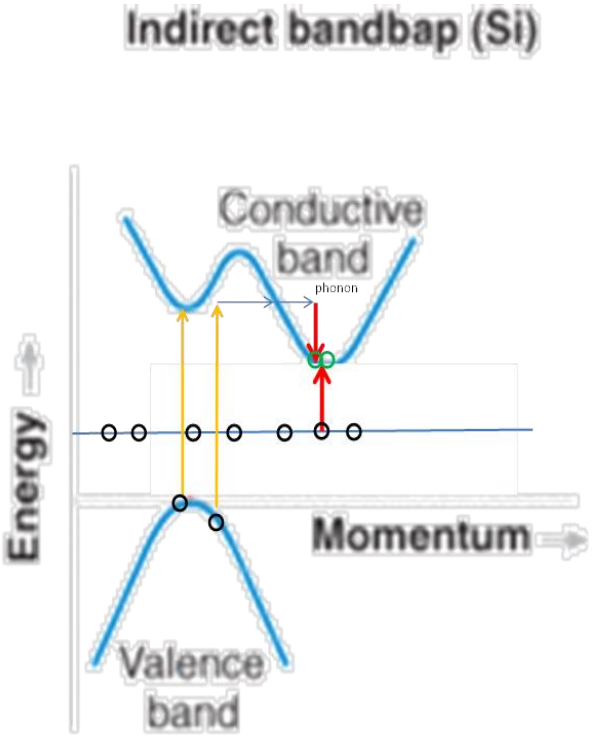
Microstrip surface





The increase of photo response related to increase of quantum yield started at ~1,4 eV, and due to a decrease of surface passivation by a high bias voltage *(our presentation at 36th RD50 Workshop)* .

Impact ionization via local levels



The impact ionization via local levels depends on a density of local level states. *(No restrictions imposed by momentum conservation.)*

It was observed by low energy neutron scattering *(our presentation at 35th RD50 Workshop)* the clusters are related to the disordered regions that consist a high density of defects.

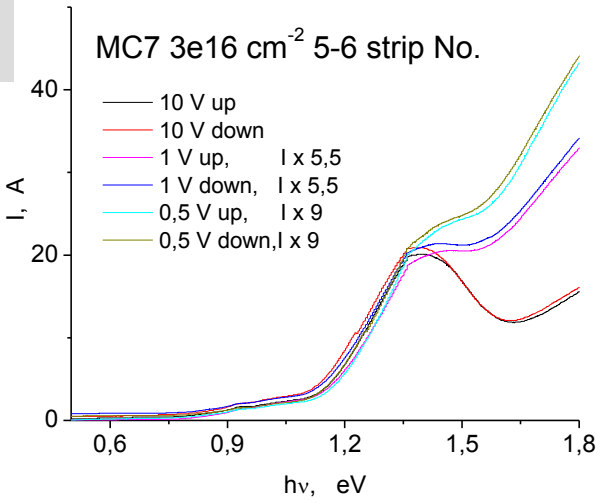
Following the author:

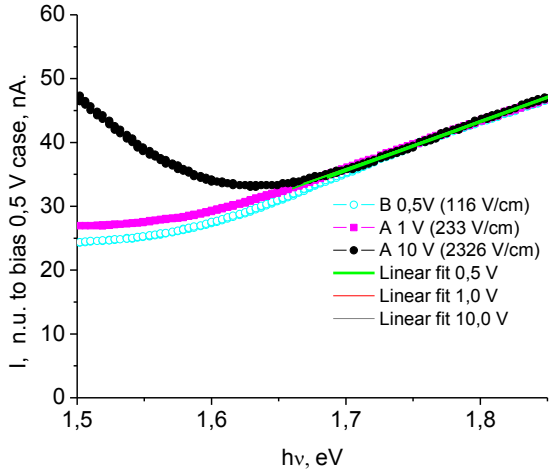
On Detailed Balance between Auger Recombination and Impact Ionization in Semiconductors

Author(s): P. T. Landsberg

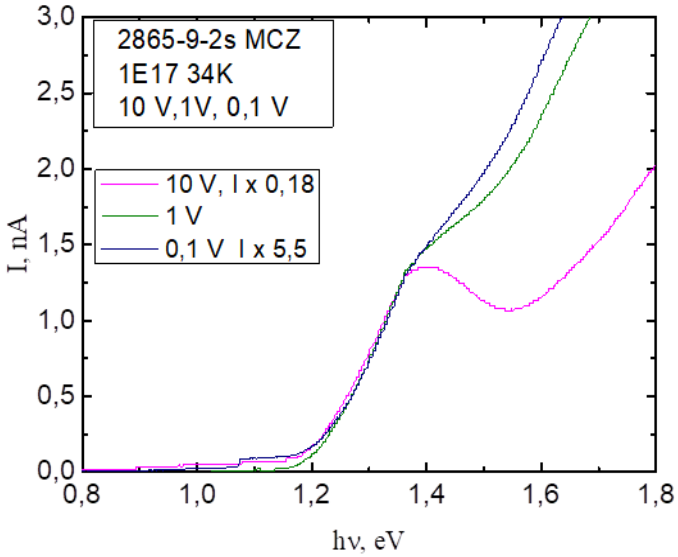
Source: *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, Nov. 21, 1972, Vol. 331, No. 1584 (Nov. 21, 1972), pp. 103-108

Fluence 3 10^{16}cm^{-2}





Fluence 1 10^{17}cm^{-2}



Conclusions:

- The effect of quantum yield enhancement was observed in neutron irradiated Si to the fluence 1e16 cm^{-2} and higher.
- It is attributed to the impact ionization via deep levels, probably related to clusters.
- The decrease of energy required for the impact ionization (~ 6 times !?) has to increase efficiency of the detectors irradiated by high fluence.

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THANK YOU FOR YOUR ATTENTION!