DLTS MEASUREMENT OF ENERGETIC LEVELS IN SILICON DETECTOR DAMAGED BY NEUTRONS

V. Sopko[1], B. Sopko[2], J. Dammer[1], D.Chren[2], J.Vlk[2], Z. Kohout[2]

1. Institute of Experimental and Applied Physics, Czech Technical University in Prague, Horska 3a/22, CZ 12800 Prague 2, Czech Republic

2. Department of Physics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Technicka 4, CZ 16000 Prague 6, Czech Republic
E-mail: vit.sopko@utef.cvut.cz

Received 30 April 2011; accepted 30 May 2011.

1. Introduction

DLTS is one of several methods for detecting and characterizing deep levels in semiconductors. Its major strength is that it is spectroscopic, i.e. it gives a unique line or peak for each deep level detected, in a way which makes it quick and easy to relate the spectrum to the concentration and energy of each defect – at least in quantitative sense. Quantitative information is obtained from the spectra with a small amount of analysis and the signatures of common defects [1].

The key to the DLTS measurement is that as the electron are emitted to the conduction band they leave behind a (net) positive charge – increasing the space charge density. Under constant voltage condition (the standard DLTS measurement) this causes the diode capacitance to increase; the depletion layer width shrinking by small amount [2,3].

Each deep level has a unique set of parameters, but more significantly the value of E_T sets the variation of emission time constant (e_n^{-1}) with temperature and hence the temperature, T_{max} of the peak. Thus each deep level produces a separate peak on the temperature axis. In general the deeper the energy level the higher the peak temperature.

2. Technology of Si detector production

Si detector is made by a standard planar technology on the N-type substrate with resistivity 2 kΩ/cm. P-type implantation is performed with boron and N-type (back side) with phosphorus with concentration 5.0×10^{15} cm^{-2}. Metallization (AlSi 1,0 Cu 0, 5) of the front side is in the order of 0,5 um and the back side of 1um. The final detector was annealed for 50 minutes at 425^{O}C in forming gas (10%H_2 in N_2). Separated detectors were irradiated in the reactor at UJV Rez with approximated dose $7,63.10^{15} n/cm^2$. The DLTS measurement was not possible to carry out on irradiated samples because of the fact that the destruction of PN junction has no capacity at all. Only TSC measurement showed a large peak corresponding to the likely fault clusters. After 10 minutes annealing at $400^{o}C$ in a nitrogen atmosphere with the initial migration of clusters of point defects of various types Figs. 1, 2, 3, 4, 5, 6, 7, 8 and in Table 1 are listed energetic levels of measured defects before and after irradiation.

3. Results

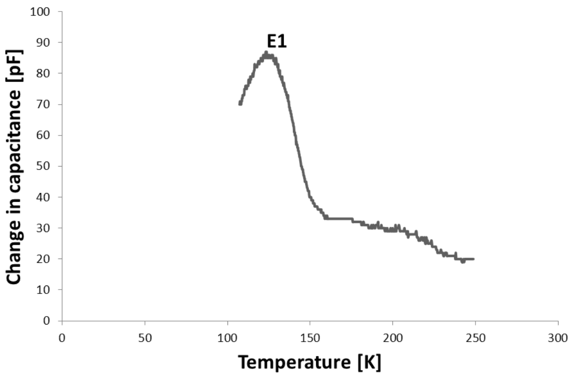

Fig. 1: *DLTS measurement for the majority charge carriers in the non-irradiated silicon*

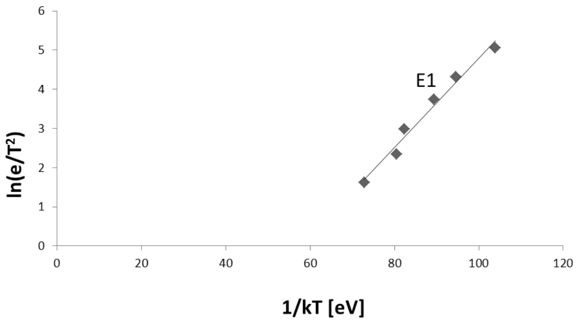

Fig. 2: *Arrhenius graph of the DLTS measurement for the majority charge carriers in the non-irradiated silicon detector*

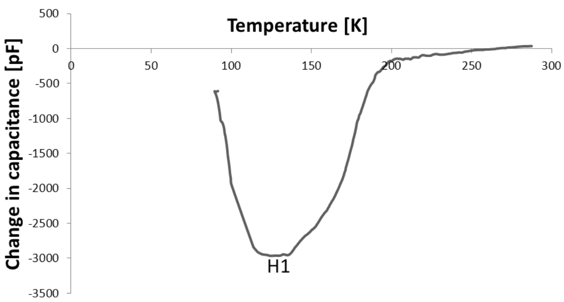

Fig. 3: *DLTS measurement of minority carrier charge in the non-irradiated silicon detector*

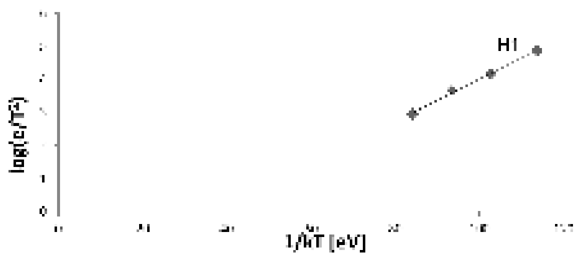

Fig. 4: *Arrhenius plot of the DLTS measurements of minority charge carriers in the non-irradiated silicon detector*

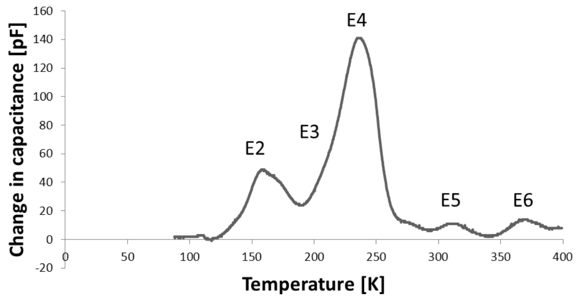

Fig. 5: *DLTS measurements for the majority charge carriers in irradiated silicon*

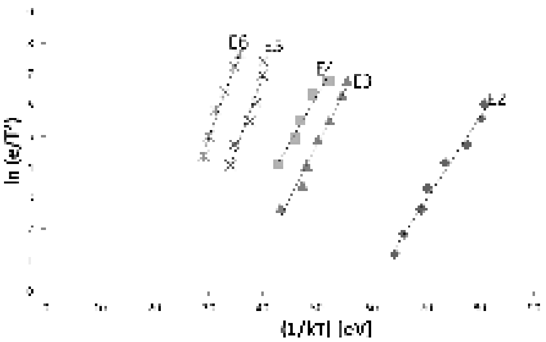

Fig. 6: *Arrhenius plot of the DLTS measurement for the majority charge carriers in irradiated Si detector*

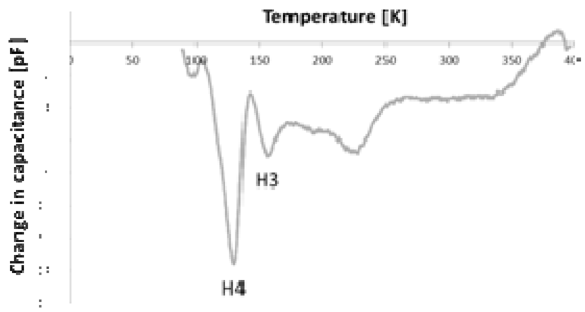

Fig. 7: *DLTS measurements of minority charge carriers in the non-irradiated Si detector*

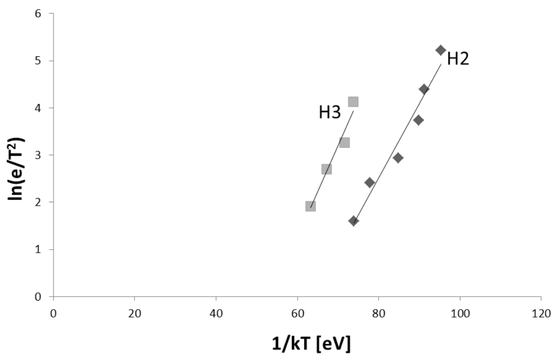

Fig. 8: *Arrhenius plot of the DLTS measurements of minority charge carriers in irradiated Si detector*

Tab. 1: *Values of energy levels before and after irradiation*

Label of Defect	DLTS before Irradiation [eV]	DLTS after Irradiation [eV]	Type of Defect [eV]	Capture Cross Section [cm^2]
H1	0,0639 eV			$4{,}96.10^{-21}$
E1	0,1140 eV			$1{,}04.10^{-19}$
H2		0,1582		$1{,}15.10^{-17}$
H3		0,1932	0,184 - [4]	$1{,}38.10^{-17}$
E2		0,2711	0,25 V V- [5]	$1{,}36.10^{-15}$
E3		0,3045	0,311 - H_2 [4] 0,300 - [5]	$1{,}15.10^{-17}$
E4		0,3447	0,341 - V_2[4]	$2{,}51.10^{-16}$
E5		0,4776		$2{,}75.10^{-17}$
E6		0,4825	0,500 - [5]	$2{,}04.10^{-18}$

4. Conclusion

The measured results show that after a high dose of neutron irradiation thus creating a number of clusters of failures, whose effects are reflected in the result in the impossibility of measuring capacity of the PN junction: only after annealing failure occurs the separation of different point defects, which have measurable energy levels in the forbidden band. We can conclude that in case of such high dose can be measured changes in VA characteristics and used measured results for dosimetry for determine dose determination. Dosimeters for high doses are used today in chemistry, sterilization, nuclear technology, in experiments with large accelerators, etc.

Acknowledgement

This work has been supported in part by the Ministry of Education, Youth and Sports of the Czech Republic under research project VZ MSM 210000029.

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