APPLICATION OF DLTS METHOD IN DEVELOPMENT OF MICROSTRIP DETECTOR TECHNOLOGY

V.V.Kuryatkov, V.F.Morozov, S.R.Novikov, T.I.Prokofieva, A.A.Kochenova*

* Scientific Research Institute "Electron", St.Petersburg

Recently a necessity has increased in the precise spatial sensitive detectors of charged particles, made of silicon with high resistivity by planar technology. In this connection an interest has arisen in methods, controlling remained impurities during technological treatment of high purity Si materials. At present one of the most sensitive methods allowing to observe the remained deep impurities in semiconductors is DLTS (Deep Level Transient Spectroscopy) [1], based on the capacitive measurement of thermal emission rates of deep levels during growth of sample temperature. It allows to determine parameters of electrical active impurities with concentration of $\geq 10^8\ cm^{-3}$ corresponding to $\geq 2 \cdot 10^{-13}$ atomic per cent.

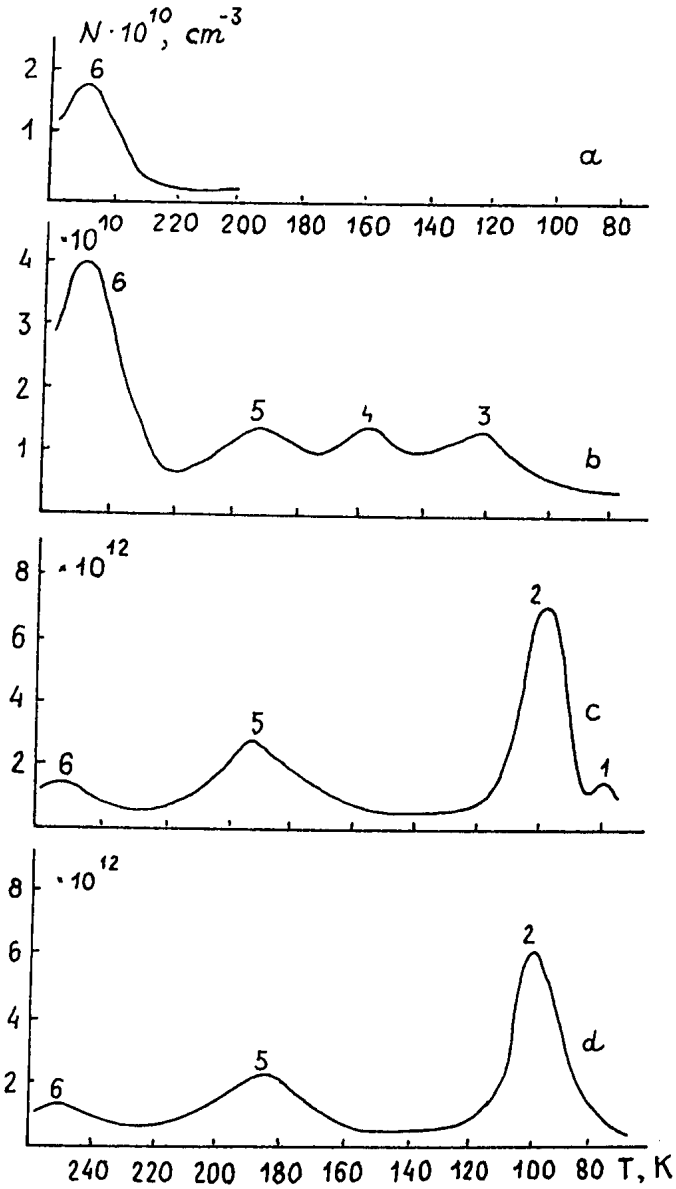

Fig. DLTS spectra of one of control samples, measured after technological operations a) — d) : a) starting wafer, b) oxidation at 1150° C, c) annealing in H_2 at 900° C, d) annealing in H_2 at 450° C

This paper presents the result of DLTS application in technological development of the microstrip detectors [2]. There was a problem of resistivity decrease of high purity n—Si during the technological treatment. It was necessary to analyze the reasons for such a decrease.

The measurement has been made by relaxation DLTS spectrometer, developed at LNPI and described in [3] in detail. The wafers of n—Si with a diameter of $60\,mm$, thickness of 300 and $500\,\mu m$ having resistivity of (1—20) $k\Omega \cdot cm$, fabricated in Zaporozhje (Ukraine) have been investigated. For this to be done the Shottky Si—Au barriers and Al ohmic contacts have been made. The testing result of several wafers has shown that concentration of the remained impurities of starting materials is less than 5% to that of the main doping impurity. Fig 1a presents DLTS spectrum obtained from a starting material. It shows the presence of impurity having a level with ionization energy $E_c - (0.49 \pm 0.03)\,eV$ and electron capture cross section $\sigma_n = 2 \cdot 10^{-16}\,cm^2$, which is probably connected with iron at concentration of $N_{Fe} \leq 10^{10}\,cm^{-3}$.

Fig. (*a—d*) presents DLTS spectra of one of the control samples measured after the process of technological operations *a)—d)*: *a)* starting material, *b)* thermal oxidation at $1150^0\,C$ in a dry oxygen with Cl doping, *c)* annealing in hydrogen atmosphere at $900^0\,C$, *d)* annealing in hydrogen atmosphere at $450^0\,C$.

Similar spectra have been obtained for other control samples. One can choose six energy levels (#1—6) with the following values of ionization energy $E_c - E$ and σ_n: #1 — $0.16\,eV$, $6 \cdot 10^{-15}\,cm^2$, #2 — $0.22\,eV$, $2 \cdot 10^{-14}\,cm^2$, #3 — $0.20\,eV$, $3 \cdot 10^{-16}\,cm^2$, #4 — $0.36\,eV$, $7 \cdot 10^{-14}\,cm^2$, #5 — $0.44\,eV$, $4 \cdot 10^{-15}\,cm^2$, #6 — $0.49\,eV$, $2 \cdot 10^{-16}\,cm^2$, correspondingly.

A new deep center (level #2 in fig *c)* has proved to appear in samples after annealing in hydrogen at $900^0\,C$. Its concentration exceeds several times main doping impurity concentration. This results in abrupt decrease of the sample resistivity. A big value of $\sigma_n = 2 \cdot 10^{-14}\,cm^2$ is due to its donor nature. The appearance of this level is probably connected with a complex between bydrogen and an electric nonactive impurity contained in starting material.

On a base of the obtained DLTS results there has been made an improvement of technological process. Instead of annealing in hydrogen at 900^0 low temperature annealing in nitrogen atmosphere is used now. This allows to exclude resistivity decrease of the material and to improve essentially the volt-ampere characteristics of the diode matrix.

References

1. Lang D.V., Topics in Appl.Phys., v.37. 1979. P.97—123.

2. Dvornikov B.D. et al. Microstrip Detector For The Track System of "HYPERON" Experiment on UNC. Preprint LNPI-1646. 1990.

3. Kuryatkov V.V. et al. An Automated Spectrometer For Measuring Deep Levels Parameters In Semiconductors. Preprint LNPI-1257. 1987.