ANNEALING STAGES IN QUENCHED ANTIMONY DOPED GERMANIUM

D. Kostoski, M. Stojić and V. Spirić
Laboratory of Solid State Physics
Institute of Nuclear Sciences "Boris
Kidrič"-Vinča, Beograd

Many works have been made to investigate the properties of thermal defects in germanium, but the nature of these defects is still under the question. The relatively high stability of thermal defects which do not anneal below 200 °C /1/ indicates that these defects cannot be identified as the single vacancies /2/. The recent experiments by Hashimoto et al./3/ who found a "fast" and "slow" annealing stage in n-Ge, reveal the complex nature of thermal defects.

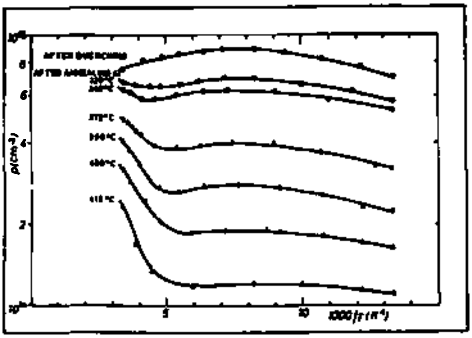

Fig 1 Temperature dependence of hole concentration after quenching and after successive isochronal anneals at indicated temperatures

In our experiments, antimony doped ($N=1.7x10^{14}cm^{-3}$) germanium singlecrystals with the dislocation density of about 10^3cm^{-2} have been used. The thermal defects were introduced by quenching the samples from 850 °C down to the liquid nitrogen temperature. The result of quenching was n-p conversion. Twenty minutes isochronal annealing by resistance heating in vacuum ($5x10^{-6}$ mmHg) has been performed after quenching. The electrical conductivity and the Hall coefficient in the temperature range 77-300K has been measured before quenching, after quenching and after each cycle of annealing.

The results are presented in Fig.1. It can be seen that annealing of a shallow acceptor level is accompanied with the appearance of a deep acceptor level (E_v+0.2eV) in the temperature range 300--350°C. At higher temperatures the concentration of this level remains constant.

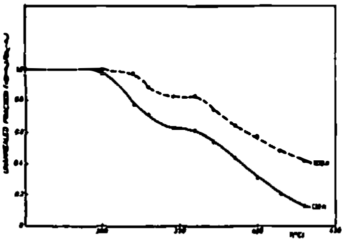

Fig.2 [illegible]

In Fig.2 the unannealed fraction $f=p+n_o/p_q+n_o$ is plotted v.s. annealing tempetures T. The carrier concenteations before thermal treatment n_o, after quenching p_q and after each annealing p refer to 130 and 300K. There are two annealing stages, the first one between 300 and 350°C and the second one above 360°C. The activation energies for annealing, determined by the change of slope method are 0.8eV and 1.2eV for the first and the second stage, respectively. The isothermal annealing shows that the process in the second stage is governed by the first order kinetic in the contrary to the first stage for which the annealing kinetic is of the higher order. The present experimental results indicate that two different defects A and B are formed during the quenching of n-Ge. The annealing of defect A leads to the appearance of an additional defect with E_v+0.2eV acceptor level. The annealing process might be connected with a long range migration of defect A resulting in formation of defect C. The annealing of defect B in the second stage most probably corresponds to the dissociation of the defect, which is vacancy cluster. New experiments are necessary for an identification of defects A, B and C.

References

1) R. A. Logan, Phys. Rev. 101 (1956) 1455.
2) R. E. Whan, Phys. Rev. 140A (1965) 690.
3) F. Hashimoto et al, Japan J. appl. Phys. 14(1975)293.