INVESTIGATION OF THE NANOSTRUCTURES FORMATION IN THE IRRADIATED BY γ – QUANTA SINGLE-CRYSTAL SILICON WITH ULTRASONIC METHOD

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ABSTRACT

It's determined that a phasic dynamics of deformation strengthening of single-crystal silicon irradiated by γ – quanta (with energy ~ 1,27 MeV) in the wide region of doses (from 10^2 up to 10^9 rad) by the internal friction measurement with widely known ultrasonic resonance method. We have detected appearance maximum on the dependence of internal friction (Q^{-1}) from dose at 10^5 rad in the samples p- Si with density of dislocations more than 10^3 cm $^{-2}$. Besides it the instability of nanodimensional dislocation structures has been established in the doses interval from 10^6 up to 10^9 rad, due to the formation and accumulation in the crystal lattice of the point like and continuous radiation defects (evolution of the dislocation densities in metals with rise of deformation were considered in [1-4]). On the temporal dependence $Q^{-1}(t)$ throughout 1,5 - 2 hours after irradiation the maximum has been established which position depends from ionizing dose. At the increasing of the observation time after stopping of the sample irradiation it is observed a monotonic decrease of $Q^{-1}(t)$ dependence, which is obviously connected with decreasing of the radiation defects densities in the result of their annihilation.

Key words: internal friction, density of dislocations, Si, radiation defects.

INTRODUCTION

A lot physical properties of materials are connected with their dislocated structure. It can be create a dislocated structure by plastic deformation or under influence of gamma irradiation [1]. Radiations damages are closely connected with dislocation strengthening. A mechanism of deformation strengthening and of formation fragmentary dislocation structures in the metals has been theoretically discussed in investigations [2, 3].

Although the processes of multiplication and of diffusion and of annihilation of dislocation in the metals and semiconductors has been considered in [2, 3, 5, 6, 7, 8], but main goal of majority investigations consist in possibility of analysis that effects from kinetics positions.

However dynamic processes of dislocation and other radiations defects after interruption of irradiation of the materials still not clear. Such information

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allows us to predetermine about resource of the semiconducting material, and about character and staging of curves of deformation strengthening, and of specific structures at mechanical fatigue of crystals. The investigation of this process importantly not only from practical standpoint but also importantly from standpoint of the description of theory of this process. In this connection it's interesting the investigation of dynamic of radiations defects in the semiconductor after stopping of influence of the radiation.

METHODS AND OBJECTS OF INVESTIGATION

Measurements of internal friction (Q^{-1}) of the single-crystal silicon have been made with ultrasonic resonance method [9] before and after irradiation.

The prismatic rods of dimensions 1x3x35мм, 1,2x4,1x28,7мм и 1x1x20мм has used in the measurements.

Ranges of value of intrinsic of the bending vibrations were varied from 20 kHz to 200 kHz. The power of vibration for stimulation of the specimen was approximately10mW. As initial specimens we used types KEF-100 and KDB-10 of single crystal of silicon.

The samples of silicon with density of dislocations more than 10^3 cm $^{-2}$ were selected for quantitative description of origin of defects in the silicon and their further evolution after irradiate of gamma-rays these samples.

Method of fixing of sample is shown on insertion b (*Fig.1*). After irradiation during 10 minutes the sample was set up between acoustic lines 1 and 3. From that time the measurement of the internal friction Q^{-1} was started.

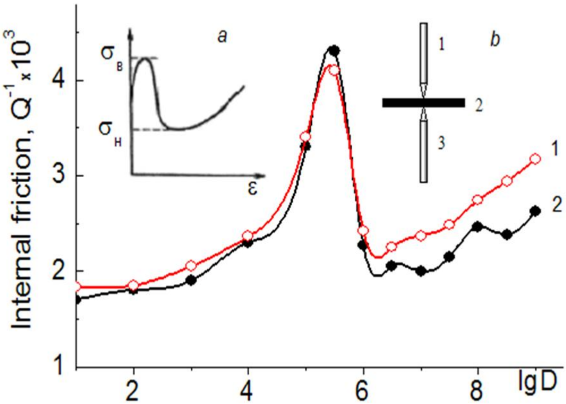

Fig. 1 – Dependence the internal friction of single-crystal of the silicon from the irradiation dose. Curve #1 is measured on frequency 149 kHz, curve #2 - 90 kHz. On insertions are shown: a- typical dependence of the tension from of the deformation which demonstrate down up tension as result of the moving dislocation formation [12]. b - method of fixing of sample where 1 is transfer acoustic line and 3 – receive acoustic line, 2-sample

RESULTS AND DISCUSSION

Dependence Q-1 from the irradiation dose is shown on *Fig.1.* It’s can to divide on three regions: I-background where Q-1 essentially not changed with increase of the irradiation dose (D) from 10 to 103 rad ; II-intermediate region where Q-1 was reached maximum with increase of D to 105 rad ; III-region where Q-1 was dropped down with increase of D from 106 до 109 rad but after that again rise.

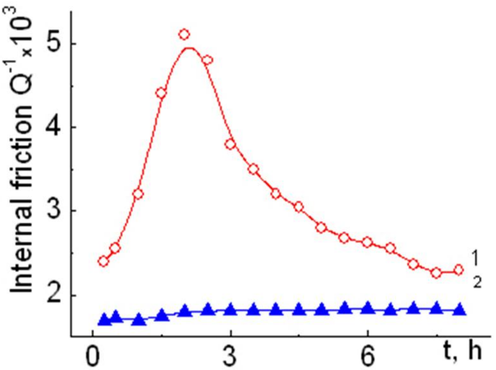

Fig. 2 – Time dependence of the single-crystal silicon internal friction after stop of the irradiation action.(1) - 10^8 rad, (2) – initial sample

On the temporal dependence $Q^{-1}(t)$ (*Fig. 2*) throughout 1,5 - 2 hours after irradiation the maximum has been established which position depends from ionizing dose.

We suppose that such behavior of the $Q^{-1}(t)$ function is connected with manifestation of migration activity which coherent with annihilation of the dislocation loops in the first 1,5-2 hours when it’s growing in 2,5 times starting from the initial up to the maximum value. At the increasing of the observation time after stopping of the sample irradiation it is observed a monotonic decrease of $Q^{-1}(t)$ dependence, which is obviously connected with decreasing of the radiation defects densities in the result of their annihilation.

CONCLUSIONS

It has been demonstrated in the present work that received dependences of internal friction (Q^{-1}) from the irradiation doses have characterized the staging step of the deformation strengthening.

We have detected appearance maximum on the dependence of internal friction (Q^{-1}) from dose at 10^5 rad in the samples p-Si with density of dislocations more than 10^3 cm^{-2}.

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