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MECHANICAL CONTROL OF INELASTIC CHARACTERISTICS, DEFECT NANOSTRUCTURE CHANGING OF SiO_2 + Si WAFER-PLATE, GeSi

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ABSTRACT

Inelastic characteristics of SiO_2 + Si, GeSi are investigated. The dislocation density and the depth of broken layer are measured for SiO_2 + Si wafer-plates. GeSi crystal with orientation [111], which periodic mechanical tension is added to, and which is under the combined influence of external electric field and magnetic field is considered.

Keywords: inelastic characteristics, elastic vibration, strains, relaxation.

INTRODUCTION

A non-destructive method for the technological control of the structure defects by measuring IF and elastic module E was developed. The study of influence of structure defects on damping of vibrations in Si + SiO_2 plates by the diameter of D = 100÷60 mm and by the thickness of $h_{SiO2} \approx 600$ nm, $h_{Si} \approx 400\,000$ nm, allows to estimate the degree of perfection of crystalline structure. The measuring of the amplitude dependence of IF allows to set the moment of a separation of dislocation segments from stoppers.

RESULTS AND CONCLUSIONS

The dislocation density are measured in limits $N_d = 10^6 \div 10^9$ m^{-2} (Shpak, 2001). The depth of the broken layer h_b = 1000÷3000 nm is on Fig. 1.

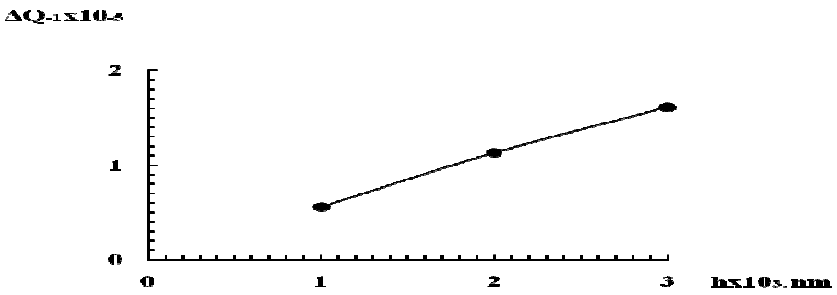

Fig. 1 - Dependence of internal friction difference ΔQ^{-1} of SiO_2 + Si wafer-plate from the depth of the broken layer h_b.

There was a small value of IF background in SiO_2 $Q^{-1}{}_0 \approx 2 \cdot 10^{-6}$ to T ≈ 385 K. A measuring error relative change of the elastic module $\frac{\Delta E}{E_0} \approx 0.5$ % (Nikanorov, 1985). The depth of

dislocation density N_D and the broken layer h_b are determined from IF difference ΔQ^{-1} on the nearby harmonics f_1 and f_2 after mechanical treatments. The dislocation density are measured in limits $N_D = 10^6 \div 10^9$ m^{-2}. The depth of the broken layer $h_b \approx 3000$ nm was. The measuring of background internal friction Q^{-1}_0 after mechanical treatments gives information about the photothermal strains fields σ_i in SiO_2 + Si wafer-plates.
Oscilloscopegramma of impulses with transversal polarization, which are reflected in SiO_2+Si wafer-plate is represented on Fig. 2.

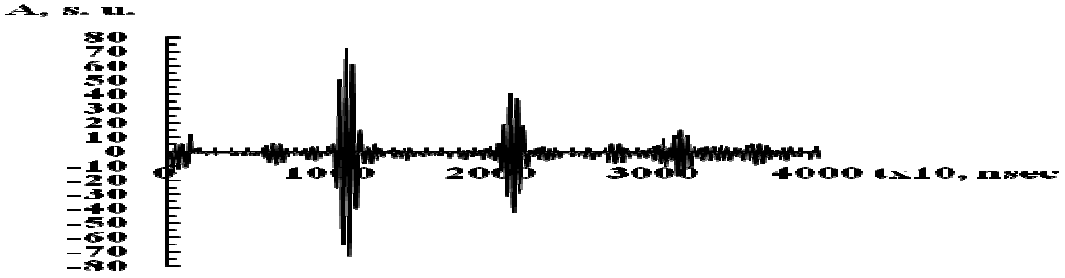

Fig. 2 - Oscilloscopegramma of impulses with transversal polarization, which are reflected in SiO_2+Si wafer-plate.

Taking into account the value of density $\rho \approx 2.63 \cdot 10^3$ kg/m^3, shear module $G = \rho \cdot v_\perp^2 \approx$ 13.91 GPa and elastic module $E = \rho \cdot v_\parallel^2 \approx 21.06$ GPa were determined.

If dislocation segment $\xi(x,y)$, that are vibrated under the act of tension τ, is charged, additional forces will operate on it $\vec{F}_E = e\rho(\xi)\vec{E}$ and $\vec{F}_M = e\rho(\xi)[\frac{\partial \xi}{\partial t}, \vec{B}]$, where $\rho(\xi)$ - is the distribution function of electrical charge density on the dislocation segment. The system of equations, which describes the movement of the charged dislocation under act of the mechanical, electrical and magnetic fields, within the framework of string dislocation model acquires the following kind:

$$M\frac{\partial^2 \xi}{\partial t^2} = V_d \frac{\partial^2 \xi}{\partial x^2} - Q\frac{\partial\ \xi}{\partial t} + b\tau - b\tau_a - N_j \frac{\partial U}{\partial \xi} + e\rho(\xi)E + e\rho(\xi)[\frac{\partial\ \xi}{\partial t}, B], \quad (1)$$

$$\frac{\partial^2 \tau}{\partial y^2} - \frac{\rho}{G}\frac{\partial^2 \tau}{\partial t^2} = \rho b \frac{\partial^2}{\partial t^2} < \int_0^\infty\ [\int_0^l\ \xi(x)dx]N(l)dl >, \quad (2)$$

where $M \approx \rho b^2$ - effective mass of unit of dislocation length, $\left(V_d \cdot \frac{\partial^2 \xi}{\partial x^2}\right)$ - force which is conditioned effective strain of bended dislocation line, $V_d \approx G\, b^2$ for screw dislocations, $V_d \approx \frac{Gb^2}{(1-\mu)}$ for line dislocations, G - the displacement module.

Thus, outcomes of an evaluation of dynamic characteristics interstitial atoms Si_j, vacancy V and O-complexes can be applied for account of a condition of an annealing with the purpose of deriving specific structural defects in SiO_2 + Si.

REFERENCES

[1]-Nikanorov S.P., Kardashev B.K. Elasticity and dislocation inelasticity of crystals. Nauka, Moscow, 1985 p. 209-221.

[2]-Shpak A.P., Kunickiy Y.A., Karbovskiy V.L. Cluster and nanostructure materials. Academy periodic, Kyiv, 2001 p. 473-486.