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DEFECT FORMATION IN BOROSILICATES BY A RESISTANCE METHOD AT γ-QUANTUM IRRADIATION

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Abstract: Influence of γ-radiation on resistance of B_2O_3/SiO_2 systems is investigated. It is shown that γ-radiation conducts to accumulation of a positive charge in volume of passivating coverings. It is established that these accumulation of a positive charge as a part of 1,5 mass.% of B_2O_3/SiO_2 is much more than in other structures. Observed effects for structure of 1,5 mass.% of B_2O_3/SiO_2 are explained by weakening of structure in sublattices at the expense of partially torn off bonds.

Keywords: *borosilicates, defect formation, γ- radiation, resistance method*

1. Introduction

Fusible and having various modification borosilicates widely are applied in semiconductor microelectronics, nuclear and space equipment. It is especially used for creation of passivating and pressurizing coverings. It caused interest to studying of influence of external influences, and in particular radiation impacts on their electrophysical characteristics. One of the key parameters defining extent of influence of radiation impacts on characteristics of passivating coverings as the indicator, is resistance size. The size of the last in borosilicates substantially depends on concentration and a way of introduction of boron in SiO_2 lattice. The variation of concentration of B^{31} as a a part of SiO_2 allows to operate over a wide range its properties that is of interest from the point of view of use of borosilicates as a perspective material not only in microelectronics, and also in radiation materials science [1-5].

The purpose of the real work consisted in studying of influence of γ-radiation on specific resistance of borosilicate and identification of defect formation type in B_2O_3/SiO_2 system.

2. Experiment technique

Measurement of specific resistance ρ of samples of B_2O_3/SiO_2 carried out four –probe dot contacts (*a, m, b, n*) method of Van-der-Pauve at a direct current and room temperature. Widespread modification of a four-probe method is the method Van-der-Pauve. This method allows to makemeasurements on samples- plates of any form. If to pass current through contacts of *am* and to measure a potential difference on *bn* contacts, the relation of U_{bn}/I_{am} will be had by dimension of resistance. Let's designate this relation of $R_{ambn.}$ Similarly, passing current through contacts of *mn* and measuring tension between *b* and *a*, we will receive other resistance of $R_{mnba.}$ The specific resistance measured by this method,

$$\rho = \frac{\pi d}{\ln 2} \frac{R_{ambn} + R_{mnba}}{2} f\left(\frac{R_{ambn}}{R_{mnba}}\right)$$

where d – thickness of a sample, f- a multiplier depending only on the relation of R_{ambn}/R_{mnba}. For dielectric measurements B_2O_3/SIO_2 was pressed in a compression mold of "Shimadzu" under pressure of 170kg/cm^2 and received a tablet with a diameter of 13 mm and 4 mm thick.

Samples were irradiated with gamma beams ^{60}Co at the room temperature with a power of dose of 0.8 Gy·s^{-1}. Measurements made by a compensation method without current selection in a chain of potential probes. This reception allows to exclude manifestation of the field of contacts of metal probes with substance.

The method Van-der-Pauve is express way of definition of $\rho$and for it the smallest error from all probe methods is characteristic. When using special samples of a clover-shape form and the accounting of special amendments on inaccuracy of probes the error of a method of measurements of specific resistance makes 10-15%. TEC 41 brand power supplies, and for power failure measurement – the voltmeter universal B7-21A were used. For ρ definition measurement of R_{ambn} and R_{mnba} was carried out in two directions of current and in calculations average values of R were used.

3. Results and discussion

In fig.1 dependences of resistance *(ρ_0)* of unirradiated samples (a curve 1) and relative change of resistance *($\Delta\rho/\rho_0$)* (a curve 2) from concentration of B_2O_3 in B_2O_3/SiO_2 system for samples 0,5; 1,5; 3 and 10 mass.% of B_2O_3 respectively after radiation are given at D=10kGy. From drawing it is visible that at increase in the maintenance of B_2O_3 in system of 1,5 mass.% of B_2O_3 value ρ_0 considerably decreases (a curve 1), and at further increase in the maintenance of B_2O_3 value of ρ_0 is almost stable. Pays on itself attention that in the irradiated examples of value of relative change of resistance *($\Delta\rho/\rho_0$)=f(B_2O_3)* linearly increase from 32 (for SiO_2) to 88% for 1,5 mass.% of B_2O_3. At further increase in the maintenance of B_2O_3 in B_2O_3/SiO_2 system value of $\Delta\rho/\rho_0$ decreases and at 10 mass.% of B_2O_3 becomes equal 31%.

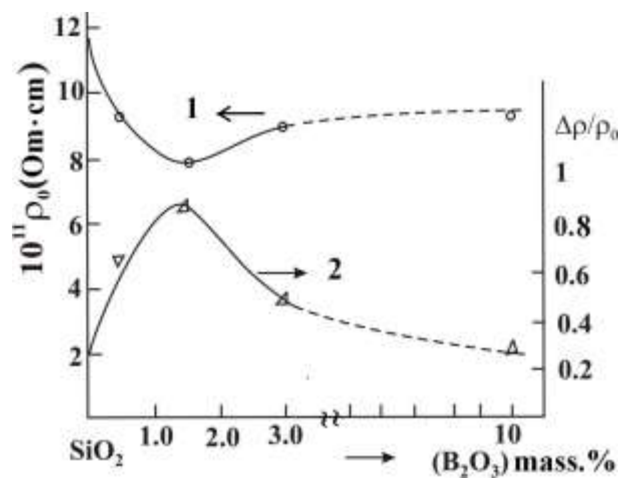

Fig.1 Dependence of resistance *(ρ_0)* of unirradiated samples (1) and relative change of resistance *($\Delta\rho/\rho_0$)* of the γ-irradiated samples (2) B_2O_3/SiO_2 at D=10 kGy.

It should be noted that initial samples of SiO_2 has hole conductivity and defective structures. Partial replacement of B_2O_3 in B_2O_3/SiO_2 system doesn't change type of conductivity. Increase in the maintenance of B_2O_3 up to 1,5 mass.% is accompanied by emergence of the chaotic centers of localization and in structure bond Si-O-Si generally remain. At the expense of the polarized chaotic centers in B_2O_3/SiO_2 system up to 1,5 mass.% of B_2O_3 monotonously decreases resistance ρ_0. As a part of 1,5 mass.% of B_2O_3 appears except Si=O=Si and B-O-B, Si-O-B of bond and in structure at further is more than torn-off bonds. At further increase in

quantity of B_2O_3 all bonds are reestablished and in samples of 3 and 10 mass.% of B_2O_3 resistance is considerably restored and passes to a steady condition. After irradiation of γ-quanta in a sample it is created additional Frenkel dot defects and due to this defect resistance strongly decreases. The greatest reduction of ρ was observed in 1,5 mass.% of B_2O_3. Under influence of γ-irradiation generally, local power conditions with the advent of Frenkel dot defects are formed. With growth of concentration of B_2O_3 studied structures pass to the steadiest condition at the expense of covalence strengthening between Si-O-B bond and relative change $\Delta\rho/\rho_0$ decreases.

Thus from experiment the following conclusions are received:

- in B_2O_3/SiO_2 system the greatest reduction of ρ is shown in 1,5 mass. % of B_2O_3 that is connected with weakening of structural communications in both sublattices.
- at increase in the maintenance of B_2O_3 in system all bonds are reestablished and system passes to a steady condition.
- after irradiation of γ-quanta Frenkel dot defects appear in samples and due to this defect resistance decreases.
- maximum relative resistance changes $\Delta\rho/\rho_0$ it is observed in 1,5 mass.% of B_2O_3 that is connected with weakening of structure in both sublattices at the expense of the torn-off bonds.

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