INFLUENCE OF HIGH REACTOR IRRADIATION ON SOME PARAMETERS OF Al_2O_3 CRYSTALS AND PROCESS GENERATION OF A SEVERAL POINTS NANODEFECTS

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ABSTRACT

In this connection the peculiarities of radiation effect on lattice parameters, form and position of several reflections, reflection coefficient and frequency of valence and deformation oscillations of Al-O bonds, optical characteristics of the oxide aluminium Al_2O_3 were studied with techniques of X-diffraction, absortion-luminescenke and IR-reflection spectroscopy. The characteristic features of the process of radiation-defect formation and generation of some points nanodefects, change in the structural, optical properties of Al_2O_3 crystals exposed to gamma and reactor radiation have been investigated by spectroscopic methods. The dose dependence's of the generation in crystals the color and luminescence centers, nanodefects - type F- and F-aggregate, change of the structural parameters was determined. For example, in work presented of temperature-dose dependence on the intensity of the 330, 420 nm bands in FL and GL spectrum of crystals. As the T= 600-700^{0}C and fluence 1.10^{16} cm^{-2} - 1.10^{19} cm^{-2} of intensity this bands increasing (nanodefects - F^+ centers) was can see. In this paper was given dose dependence of generation on the oxide in the absorption spectra a bands 257 and 358 nm (nanodefects of a type F- and F-aggregate defects). The possible mechanism of damage structure of a samples irradiated in a reactor is discussed.

Key words: nanodefects, F^+ centers, FL and GL spectrum, oxide aluminium, absortion-luminescenke spectroscopy, reactor radiation, dose dependence's.

INTRODUCTION

Al_2O_3 oxide is one of the prospective high-k electro-insulators und construction oxides materials, in partocular, for the ceramical fuel material and for a first wall thermonuclear arrangement. Besides, this oxide used widely as an active element or substrate at creation of laser and MOS systems, as a film coating and receiver of IR-radiation [1-7]. From here this work aim at investigation of radiation stability of the physical properties and a structure of Al_2O_3 crystalline oxide after irradiated in the reactor of a high fluence and cource Co^{60}.

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RESULTS AND DISCUSSION

In this connection the peculiarities of radiation effect on lattice parameters (a, c), form and position of several reflections, reflection coefficient and frequency of valence and deformation oscillations of Al-O bonds, electric characteristics of the oxide were studied with techniques of X-diffraction, dielectric, optic and IR-reflection spectroscopy.

The fracture our maximum on the dose curves Y(F) of intensity photoluminescence (FL) at 330, 390 and 510 nm, colour centers 205-460 nm and 570 nm in the range of identical doses was determined at the analysis of the obtained results. *Fig. 1* presents the temperature-dose dependence of the intensity of the 330 nm band in FL spectrum of crystals. As the T= 600-700^{0}C of intensity this band increasing, this can be used in creating tunable lasers [4].

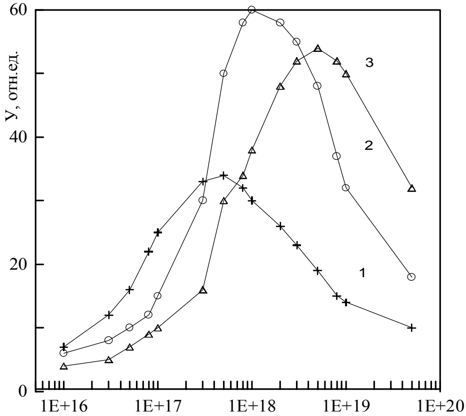

Рис.1 Температурно-дозовая зависимость интенсивности полос ФЛ 330 нм: кривая 1, T= 300 C; кривая 2, T= 600 C; кривая 3, T= 700 C.

A similar kinetics of a process of decolouration of 510 nm FL band was established when temperature was varied. On the basis results obtained that the temperature dependence of photodecoloration of this band has an extremum character, because the maximum rate up to T>900^{0}C on a change in the time UV illumination of plates from 0 to 600 sec. The $I/I_0(\Phi, T, t)$ graphs obtained can be approximated by exponential dependence's of the formula

$$I = \sum I_i^o \exp(-\alpha_i t), \qquad (1)$$

where α_i - constant of decay (i = 1-3), which is a function of temperature and dose.

For example, in present communication it is submitted the results of X-ray structure investigation of after irradiation by high neutron doses (F). X-diffraction patterns were obtained using a roentgen diffractometer. Particular attention was given to dynamics of form and positions some representative reflexes with hkl = 014, 110, 03.12 and ets. The diffraction patterns were found essential changes of peak intensity and position depending upon F, the Bragg angle 2Θ decreases with an increase in dose, the regularity is shown if $K\alpha_1$ and $K\alpha_2$ doublet is splintered. For example, on *figure 2* was given to radiation dynamics of the function 2Θ (F) for this doublet ($K\alpha_1$ and $K\alpha_2$) in the reflexes 03.12.

From fig. 2 is shown that the displacement of this peak $\Delta(2\Theta) = 40\text{-}50^0$ at doseF=10^{20}-10^{21} cm^{-2}. At high doses the reflexes at $2\Theta > 70^0$ are eroded and weakened and doublets are not splitting, the lattice parameters of crystals (a, c, d/n - tab.1) was undergoes anisotropy expansion, at very high dose of change this parameters is composed not so many as Δc= 0,0038 nm and Δa = 0,0014 nm.

Table 1. Influence of neutrons on some parameters of crystals.

F, cm^{-2}	5.10^{16}	1.10^{17}	5.10^{17}	1.10^{18}	5.10^{18}	8.10^{18}
D_1, a.u.	0,18	0,27	0,34	0,62	1,29	1,29
D_2, a.u.	0,10	0,12	0,15	0,35	0,51	0,64
F, cm^{-2}	8.10^{18}	1.10^{19}	5.10^{19}	8.10^{19}	1.10^{20}	5.10^{20}
D_1, a.u.	1,29	1,27	1,28	1,70	1,95	2,15
D_2, a.u.	0,64	0,93	1,05	1,00	1,21	1,99
c, nm	1,298	1,298	1,298	1,299	1,300	1,301
d/n, nm	0,2379	0,2379	0,2380	0,2381	0,2383	0,2386
$(2\Theta)^o$	89,04	89,03	88,99	88,98	88,95	88,86

In table 1 was given dose dependence of generation in the absorption spectra a bands 257 and 358 nm (D_1, D_2, F- and F-aggregate defects). The mechanism of atom displacement out of lattice knots plays the main role in radiation damage of irradiated of high doses crystals.

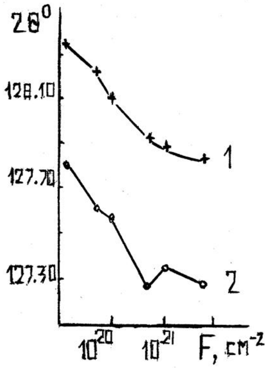

Fig. 2 – Dose dependence of 2Θ (F) for doublet $K\alpha_1$ (1) and $K\alpha_2$(2) of reflexes 03.12

The optical characteristics - a reflection coefficient and frequency of valence (736, 614cm^{-1})and deformation (464cm^{-1}) oscillations of Al-O bonds of the oxide were studied with techniques of IR-reflection spectroscopy in region 400-1200 cm^{-1}. The partify decrease of intensity (R) and frequency (ν) of this modes at fluence 8.10^{19} cm^{-2} was observed. The change of these parameters were found near a neutron fluence (6-8).10^{19} cm^{-2}.Some change of these optical (valence and deformation oscillations of Al-O bonds) and structural parameters (the lattice parameters of crystals (a, c, d/n) and positions some representative reflexes, of peak intensity and the Bragg angle), a density and a linear size of irradiated samples were found near a neutron fluence 10^{20} cm^{-2} and 10^{21} cm^{-2}, but the structure state remained stable at the following increase of the irradiation dose (at F= 1.10^{21} cm^{-2} and 7.10^{21} cm^{-2} and higher).

CONCLUSIONS

Thus, such thermal-radiation treatment may serve as a method leading to the permittivity growth at elevated irradiation doses and temperatures, decrease and improvement of several physical and optical characteristics of the oxide Al_2O_3. A conclusion about the radiation-induced modification of the optical and structural parameters of crystals, nonlinear generation of point nanodefects, a possible their at solution for a problems of the management optical properties oxides. The removal about the action of large fluences neutron on the order of a structure, a parameters of lattice and the formation of region of disordering at the places of accumulation of the radiation defects as a result of implementation of the mechanism of displacement of atoms in the crystal lattice of a dielectric has been made.

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