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Anomalous Behaviour of $MgO \cdot 2.5\ Al_2O_3$ under Radiation

By

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Single crystals of magnesium-aluminium spinel ($MgAl_2O_4$) are highly expectative both for practical use in microelectronics and as an efficient model for studying optical properties of spinel-lattice-structure compounds. The spinel structure is known to exist at Al_2O_3/MgO molar-ratio increase up to 7 /1/: excess aluminium ions occupy tetrahedral lattice sites in that case, and vacancies appear in octahedral sites /2/. The fast neutron radiation effect upon compounds with the spinel-lattice structure /3/ causes two- and three-valence cation redistribution in tetrahedral (8a) and octahedral (16d) positions of the crystal lattice.

This note presents a study on the fast neutron radiation effect upon the cation distribution in non-stoichiometric single crystals of spinel ($MgO \cdot n\ Al_2O_3$ where n = 2.5). The cation distributions are monitored by Cr^{3+} ions.

$MgO \cdot n\ Al_2O_3$ single crystals were grown by the Verneuil method. Micro- and macrocomponent quantities have been found by the instrumental neutron activation analysis technique, the results are presented in Table 1.

Table 1

Macro- and microcomponent contents of $MgO \cdot n\ Al_2O_3$ single crystal

macrocomponent contents of $MgO:Al_2O_3$		impurity contents (mass%)		
introduced	obtained	Cr	Mn	Fe
1:2.8	1:2.5	2.6×10^{-4}	2.4×10^{-5}	5.4×10^{-4}

The IRT reactor of the Institute of Physics (Academy of Sciences of the Latvian SSR) served as a source of fast neutrons with fluence of up to 10^{16} cm^{-2}, the exposure temperature being not higher than 373 K.

Fig. 1 presents absorption spectra of $MgO \cdot 2.5\ Al_2O_3$ single crystal. After exposure to a fluence of 10^{16} cm^{-2} there appears an intensive absorption at $\lambda < 280$ nm and 305, 355, and 470 nm, which is quite similar to the effect of neutron irradiation on α-Al_2O_3:Cr single crystals. Fig. 1 presents additional absorption

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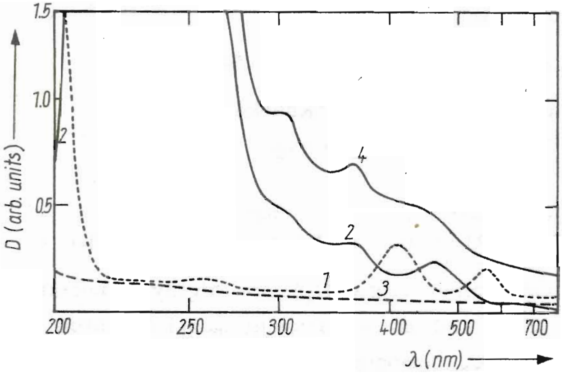

Fig. 1. Absorption spectra of α-Al_2O_3:Cr: (1) before irradiation, (2) additional absorption spectrum initiated by a fast-neutron fluence of 10^{16} cm^{-2}, and of MgO · 2.5 Al_2O_3 (3) before irradiation, (4) after irradiation by a fast-neutron fluence of 10^{16} cm^{-2}

spectra initiated by the fluence of 10^{16} cm^{-2} and the non-irradiated α-Al_2O_3 spectrum. The band positions coincide.

After neutron radiation on single crystals of MgO · 2.5 Al_2O_3, the photoluminescence spectra of Cr^{3+} differ greatly from those of synthetic MgO: Al_2O_3, for which, as has been found in /4/, an increase in the conversion degree is observed.

Fig. 2 demonstrates the photoluminescence spectrum for MgO · 2.5 Al_2O_3 crystal. Before irradiation a Cr^{3+} spectrum which is characteristic of magnesium-aluminium spinel with cation inversion is observed. That spectrum consists of the so-called N-lines only /5/. After irradiation by 10^{16} cm^{-2} fluence there appear two broad bands with maxima of 470 and 580 nm, and the Cr^{3+} luminescence

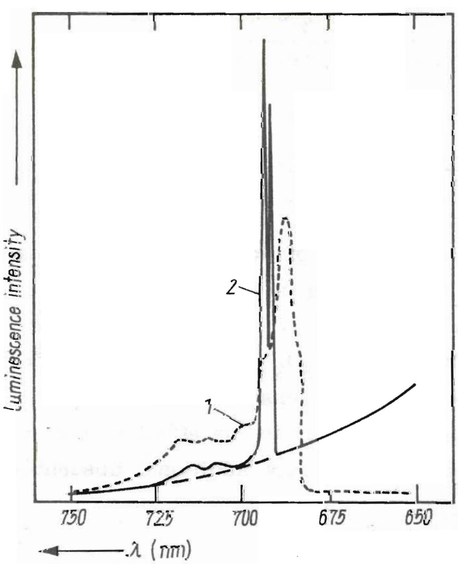

Fig. 2. Photoluminescence spectra of MgO · 2.5 Al_2O_3: (1) before irradiation, (2) after irradiation by a fast-neutron fluence of 10^{16} cm^{-2}

spectrum changes completely (the luminescence spectra are obtained at λ = 400 nm excitation). The Cr^{3+} luminescence spectrum in the irradiated $MgO \cdot 2.5\ Al_2O_3$ single crystal has been compared to that of α-Al_2O_3:Cr. The positions of sharp lines coincide with the positions of R_1 and R_2 lines for α-Al_2O_3:Cr crystal.

The above findings allow the conclusion that irradiation of $MgO \cdot 2.5\ Al_2O_3$ single crystal causes formation of an α-Al_2O_3 local structure around the Cr^{3+} ions.

References

/1/ R.H. ARLETT, J. Amer. Ceram. Soc. 45, 523 (1962).
/2/ R. DUPREE, M.H. LEWIS, and M.E. SMITH, Phil. Mag. A53, L17 (1986).
/3/ YU.G. CHUKALKIN, B.N. GOSHCHITSKII, S.F. DUBININ, S.K. SIDOROV, V.V. PETROV, V.D. PARKHOMENKO, and V.G. VOLOGIN, phys. stat. sol. (a) 28, 345 (1975).
/4/ V.N. SKVORTSOVA, Ph.D. Thesis, Academy of Sciences of the USSR, Institute of Physical Chemistry, Moscow 1988.
/5/ J. DERKOSCH and W. MIKENDA, J. Lum. 28, 431 (1983).

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