INVESTIGATION OF THE CHROMIUM IONS RECHARGING KINETICS IN Cr,Mg:YAG EPITAXIAL FILMS DURING HIGH-TEMPERATURE ANNEALING

O. Buryy[1], S. Ubizskii[1], I.I. Syvorotka[2], K.-D. Becker[3]

[1] Lviv Polytechnic National University, Lviv, Ukraine
[2] Scientific Research Company „Carat", Lviv, Ukraine
[3] Institute of Physical and Theoretical Chemistry, Technical University Braunschweig, Braunschweig, Germany
E-mail: crystal@polynet.lviv.ua

The optical absorption spectra of Cr,Mg:YAG epitaxial (LPE) films are studied at *in-situ* conditions during high-temperature annealing in oxidizing and reducing atmospheres. The spectra are measured in the spectral range from 200 to 2000 nm at temperatures up to 1100 K. The kinetics of optical absorption changes are registered at the wavelength of 450 nm that is approximately corresponds to the center of the absorption band caused by Cr^{4+} in the octahedral (octa) cites.

As well as in the case of the bulk Cr,Mg:YAG crystals [1], the oxidation leads to recharging of chromium ions Cr^{3+}(octa) → Cr^{4+}(octa), whereas the reduction causes the backward process. At that the migration of Cr^{4+} ions from the octahedral sites to the tetrahedral ones is negligible for the temperatures up to 1100 K. The main peculiarity of the oxidation kinetics of Cr,Mg:YAG epitaxial films in comparison with the ones of the bulk crystals is the absence of non-monotony that is specific for the bulk crystal [1]. Obviously, this difference is caused by the higher structural perfection of the films obtained by liquid phase epitaxy that inhibits the formation of the defects typical for the bulk crystals.

The experimental redox kinetics are successfully described by the mathematical model that takes into account the out-diffusion of oxygen vacancies during oxidation and their in-diffusion during reduction. The vacancy diffusion coefficient obtained from fitting of the reduction kinetics increases from $(7.67\pm0.06)\cdot10^{-7}$ cm^2/s at 936 K to $(7.90\pm0.11)\cdot10^{-6}$ at 1091 K. Simultaneously the mass-transfer coefficient of the oxygen transport from the crystal surface to surroundings increases from $(1.513\pm0.013)\cdot10^{-5}$ cm/s to $(1.70\pm0.02)\cdot10^{-4}$ cm/s. The activation energies of the diffusion and mass-transfer processes, obtained from their temperature dependencies, are equal to 1.34 ± 0.04 eV and 1.36 ± 0.05 eV correspondingly.

The comparison between the values of the diffusion and mass-transfer coefficients obtained for the Cr,Mg:YAG film and for the bulk crystal at the close temperatures shows that the transport processes in the epitaxial films are essentially faster than the ones in the bulk crystals. Particularly, the activation energies of diffusion is approximately in 1.5 times lower and, correspondingly, the diffusion coefficient is approximately in one order higher for Cr,Mg:YAG epitaxial films.

References

[1] O. Buryy, S. Ubizskii, A. Börger, K.-D. Becker, Phys. Stat. Sol. (a) **206** (2009), 550.