Ga_2O_3 – A NEW PROSPECTIVE MATERAL FOR THz DOMAIN

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Gallium oxide (Ga_2O_3) is known as transparent semiconducting material existing as five (α, β, γ, δ, and ε) polymorphs. Obtaining a crack-free, and high structural and optical quality single crystal Ga_2O_3 is difficult due to enhanced decomposition of Ga_2O_3 and the melt/vapor interaction with the crucible. At high temperatures (>900 °C) only β-phase, with a melting point of from 1820 ˚C to 1900 ˚C, is stable. β-Ga_2O_3, having a monoclinic system, belongs to the *C*2/*m* group symmetry class of materials that can be grown from the melt. As a semiconductor, it shows outstanding physical properties: hardness, thermal and chemical stability and therefor widely used in electronics. No application in optics were reported [1].

In this work, we studied its optical properties in the entire transparency range; in the THz domain, it was studied for the first time. In fact, there is strong depending of optical properties on the growth technology.

To produce the β-Ga_2O_3 powder hydrothermal technique was used. Ga was put in hot (~ 60 °C) water for three 30-minite cycles. Formed $GaO(OH)\times H_2O$ hydroxide was extracted from the water and dried at 60-80 °C. It chemical formula and type of structure were confirmed by XRD, Raman and IR spectroscopy. It was shown that compound belong to orthorhombic *Pnma* space group (denoted as Ga-60), it was also confirmed by TEM, that shows that powder consist of micron and submicron orthorhombic particles.

After drying, mixture was annealed at 600, 900 and 1100 °C (denoted as Ga-600, Ga-900 and Ga-1100). Ga-900 and Ga-1100 are found to be pure β-Ga_2O_3 in comparison with Ga-600, which contains both: trigonal *R*-3*m* and monoclinic *C*2/*m* phases (Fig. 1b). It is necessary to note, that annealing changes structure of the initial mixture and leads to enlarging and agglomerating of powder into sub-micron structures with monoclinic symmetry that can be clearly seen at Fig. 1a.

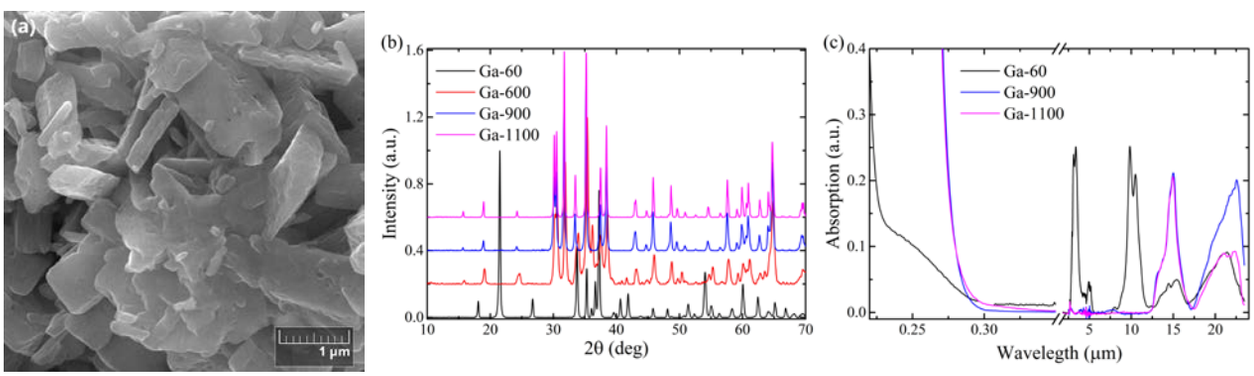

Fig. 1. (a) SEM-photo of Ga-1100 powder; (b) X-ray powder diffraction spectra; (c) VIS-IR absorption spectra.

Main transparency window is found to be from 0.280 μm (Fig. 1c) to 12.5 μm. In order to study THz properties of tested materials, THz spectrometer with time resolution (THz TDS) was used. During the measurements, powders of selected samples were placed in 1 mm thick polyethylene cell. Measured results were compared with those from the study of samples grown by chemical vapor transport technique that well matches each other. β-Ga_2O_3 shown attractive anisotropy of refractive index (up to 0.22) and small, down to 2–3 cm^{-1}, absorption coefficient at room temperature. So, β-Ga_2O_3 is likely to be very attractive material for fabrication different optical parts for the THz domain.

REFERENCES

[1] *Z. Galazka, R. Uecker, D. Klimm, K. Irmscher, M. Naumann, M. Pietsch, A. Kwasniewski // ECS Journal of Solid State Science and Technology. – 2017. – Volume 6. –№ 2. – P. 3007-3011.*