

Challenges on the way to the experimental observation of GaN melting

B. Sadovyi^{1,4}, S. Porowski¹, S. Stelmach¹, I. Petrusha², V. Turkevich², S. Boccato³,
I. Karbovnyk⁴ and I. Grzegory¹

¹ *Institute of High Pressure Physics PAS, Sokolowska str. 29/37, 01-142 Warsaw, Poland*

² *V. Bakul Institute for Superhard Materials NASU, Avtozavodska str. 2, 04074 Kyiv, Ukraine*

³ *ESRF-European Synchrotron Radiation Facility, Martyrs str. 71, 38043 Grenoble, France*

⁴ *Ivan Franko National University of Lviv, Dragomanova str. 50, 79005 Lviv, Ukraine*

Gallium nitride (GaN) is considered to be one of the most important semiconductors in state-of-the-art electronics [1]. Two types of experimental approaches intending to solve the longstanding puzzle regarding the pressure evolution of the melting temperature $T_m(p)$ of GaN are discussed.

The first part of the analysis is based on (i) studies of the decomposition curve in p - T plane corresponding to the transformation of solid GaN into the liquid Ga and gaseous N_2 , in the pressure range extended up to $p = 9$ GPa, (ii) the novel method of $T_m(p)$ estimation for GaN using the scaling analysis of experimentally obtained nitrogen solubility in gallium and (iii) the pressure invariant parameterization of the $T_m(p)$ curve. As the result, the comprehensive experimental data [2, 3, 4] and the most relevant theoretical predictions [5, 6] are compiled in an effort to construct a part of p - T phase diagram that shows the minimal pressure and temperature values at which GaN melting is possible prior to decomposition.

The second step, related to experimental studies of GaN phase diagram in wide pressure and temperature ranges, is based on *in situ* measurements of GaN structural transformations (melting and solid-solid phase transition) induced by pressure and temperature using Extended X-ray Absorption Fine Structure (EXAFS) Spectroscopy. Obtained Ga K-edge EXAFS spectra of GaN are analysed and their preliminary interpretation are discussed. Some conclusions related to GaN wurtzite-rocksalt solid-solid transition induced by pressure and by heating and initial estimation of melting of GaN in its rocksalt phase at 55 GPa will be presented. These experimental results lay the background for obtaining improved gallium nitride p - T phase diagram.

[1] B. Gil, *III-Nitride Semiconductors and their Modern Devices*, ed. R. Nicholas and H. Kamimura, 2013, Oxford: Oxford University Press. 638.

[2] J. Karpinski, J. Jun, and S. Porowski, *J. Cryst. Growth* **66**, 1 (1984).

[3] W. Utsumi et al., *Nat. Mater.* **2**, 735 (2003).

[4] S. Porowski et al., *J. Phys. Chem. Solids* **85**, 138 (2015).

[5] J.A. Van Vechten, *Phys. Rev. B* **7**, 1479 (1973).

[6] K. Harafuji, T. Tsuchiya, and K. Kawamura, *J. Appl. Phys.* **96**, 2501 (2004).