On Optical Parameters of Wide Band Gap Semiconductors

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One of the most important information for thin layer of semiconductor grown for technical applications is the thickness of it. It can be established on the basis of interference phenomena knowing the value of index of refraction with great enough accuracy. On the other hand, an information of such value and its dependence on wavelength is needed for microstructure engineering. Usually such studies are limited either to mid infrared [1] or visible range [2].

The modern technology produced such crystals with much higher quality than these a dozen or so years ago. The goal of our work is to establish the precise value and dependence of index of refraction for wide band gap materials, namely GaN and SiC, in the full spectral range starting in the middle infrared region up to ultraviolet one.

The GaN samples studied are bulk crystals grown by ammonothermal method and MOCVD epitaxial layers grown both on sapphire and GaN substrates. The SiC crystals were commercially available substrates from CREE. The infrared measurements were done with Fourier transform spectrometer Bruker 113v. In the visible and UV range the Cary 5000 spectrometer was used. In the transmission and reflectivity spectra the clear interference fringes were observed. In the case of GaN we combine the results obtained for thick bulk crystal for which the thickness is known with high accuracy, with those obtained for epilayers, where the fringe order for a given interference minimum/maximum can be precisely determined.

The reflectivity measured in the mid infrared was fitted with theoretical curve obtained from Dynamic Dielectric Function (DDF) taking into account only TO phonon mode and plasma contribution. The obtained parameters have been used to establish values of index of refraction in the mid infrared region and based on interference phenomena we could extend the analysis on full spectral range. The obtained dependence has been parameterized with phenomenological Sellmeier equation [3]. To understand the physical mechanisms responsible for observed dispersion we use, within DDF, the model that includes the contributions of plasma, TO phonon mode, excitonic absorption in the near UV, as well as optical transitions to the higher electronic bands. The same parameters were used to describe the interband absorption coefficient measured with one of the layers. Similar analysis has been performed in the case of SiC. Due to different energy band structure the effect of interband transitions on infrared refractive index is found to be much smaller than in GaN crystals.

Concluding, combining the results obtained for samples with different thickness we could establish, with high precision, refractive index of high quality GaN and SiC, and correctly identify the physical mechanisms responsible for the observed dispersion.

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[1] A. S. Barker Jr and M. Ilegems, *Phys. Rev. B* **7,** 743 (1973).
[2] C. X. Lian, X. Y. Li, and J. Liu, Semicond. Sci. Technol. **19**, 417 (2004).
[3] W. Sellmeier, *Annalen der Physik und Chemie* **219**, 272-282 (1871).