Surface control of light-emitting structures based on III-nitrides

A.I. Besyul'kin[a], A.P. Kartashova[a], A.G. Kolmakov[b], V.V. Krivolapchuk[a], W.V. Lundin[a], M.M. Mezdrogina[a], A.V. Sakharov[a], N.M. Shmidt[a#], A.A. Sitnikova[a], E.E. Zavarin[a] and R.V. Zolotareva[a]

[a] Ioffe Physico-Technical Institute, St. Petersburg 194021, Russia
[b] Institute of Metallurgy, Moscow 117911, Russia
[#] Natalia.Shmidt@mail.ioffe.ru

In spite of excellent success in the light-emitting devices technology, the mechanism of effective radiation recombination is not clear yet. The major part of the investigations is devoted to effects of the inhomogeneity of the In incorporation into InGaN, of the layer thickness in MQW InGaN/GaN structures, and of the dislocation density on the radiation recombination efficiency. However, the papers regarding the influence of an extended defect system, including dislocations and a mosaic structure, on optical properties of the light-emitting structures (LES) are not numerous. Recently [1,2] it has been demonstrated that a surface control of GaN epilayers allows the extended defect system peculiarities to be quantitatively characterized using multifractal parameters.

The multifractal analysis (MFA) allows structure material peculiarities to be characterized as a whole and the internal bindings to be revealed between the parts of complicated structure using the following parameters: the level of self-organization (D), the degree of disruption of local (the degree of order Δ) and general symmetry.

In the present paper the results on the comparative investigations of photoluminescence (PL) and delayed photoluminescence spectra, electroluminescence (EL) spectra of LES based on MQW InGaN/GaN grown by MOCVD on (0001) sapphire substrates have been presented. LES had a different degree of order of mosaic structure Δ. The investigations had revealed the significant difference not only in the forms of PL and EL spectra, but also in the peak intensity. Maximum intensity of the PL and EL spectra was observed in LES with the well-ordered mosaic structure ($\Delta < 0.33$). The delayed spectra of these structures had a single clear peak, while many peaks with the low intensity were observed in LES with the poor-ordered mosaic structure ($\Delta > 0.33$). These data together with the data on a TEM investigation of LES with different Δ will be discussed.

Thus the degree of order of the extended defect system influences the electroluminescence efficiency essentially. The surface control using the multifractal parameters can be applied to optimize the properties of LES and the process of their creation. Moreover, it is very important that surface control can be realized in each stage of technological process. The Δ effect on the tunnelling light-emitting recombination has been discussed.

[1] N.M. Shmidt, et al. *Inst. Phys. Conf. Ser.*, **169**, 303 (2001).
[2] A.V. Ankudinov et al. *Physica B*, **340-342**, 462 (2003).