Two modes of luminescence energy control in polar and semipolar InGaN/GaN quantum wells

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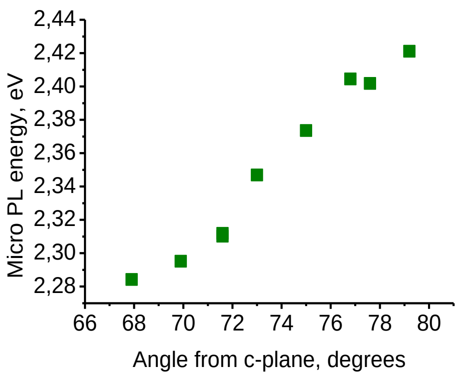
The majority of InGaN quantum structures are grown on c-plane polar substrate orientation in the step-flow growth mode. In such case indium composition (and so the bandgap) is determined mostly by the growth temperature and directly influences the energy of emitted light. However, it was shown that indium content also depends on the substrate miscut angle (with respect to the c polar plane). We have investigated structural and optical properties of such structures as a function of miscut and the main observations are as follows: i) indium content decreases and bandgap increases for higher miscut angle, ii) photoluminescence decay time decreases for higher miscut, which is due to both lower indium content and weaker quantum confined Stark effect.

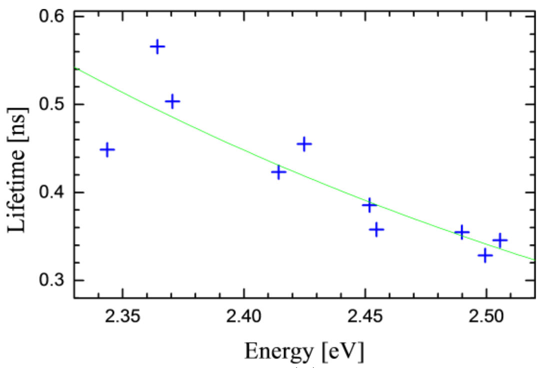
In this work we focused on similar research for InGaN structures grown on semipolar (20-21) plane, for which internal field is strongly reduced. In contrast to growth on the polar plane, it turned out that indium content did not depend on the substrate miscut, what was confirmed by XRD. However, in contrary to the expectations the following results were achieved: both emission energy and luminescence decay time were sensitive to the miscut angle. We show that these effects can be attributed solely to the variation in built-in electric field.

According to calculations performed by Wernicke and coworkers [1] the internal field magnitude should depend on the semipolar substrate miscut angle and has spontaneous (along the c-axis) and piezoelectric (due to strain in the growth plane) components.

We will also discuss results for polar and semipolar structures, in terms of the growth mode and carrier recombination mechanisms.



(a)



(b)

Fig. 1. a) Luminescence energy as a function of substrate miscut angle for 5QW structure grown on (20-21) plane GaN. b) Luminescence decay time as a function of energy for the same sample.

[1] T. Wernicke et al., Semicond. Sci. Technol. **27**, 024014 (2012).