Achieving monolithic wideband InGaN/GaN LED arrays.

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One of the most important parameters in epitaxial growth is the miscut angle of the substrate. It governs kinetic processes on the growth front and influences structural, optical and electrical properties of the structures. In our previous works we have demonstrated that a controllable modification of the miscut along the substrate surface offers a valuable variety of new ideas leading to interesting applications. They rely on the effect of decreasing In-content in InGaN with increasing the tilt angle of the substrate and the effect of rising hole charge concentration in Mg doped GaN grown on substrate with higher slope angle.

In the present work, we succeeded to fabricate InGaN/GaN light emitting diodes (LED) with a variation of wavelength originating from lateral arrangement of differently tilted substrate by use of a special photolitography and ion etching techniques. The slope angle changed in range from 0.1 to 2.5 degrees. After the growth of InGaN layers, indium concentration changed with respect to the tilt angle, what results with the change of bandgap and the luminescence wavelength. In this way, monolithic, multicolor LED arrays were obtained. In one of them, photo- and electro-luminescence range was from 510 to 481 nm, what means change from green to blue color of the emitted light on one wafer.

Besides the demonstration of a useful emitter we obtained an experimental tool for studying microscopic processes of light emission from InGaN/GaN quantum structures characterized by different concentration of indium. The light emission dynamics was studied with the use of time–resolved photoluminescence spectro-scopy. It has been found that photoluminescence energy and decay time depended on voltage that changed electric field inside the structure and modified the Stark effect. The other consequence of such situation was ~~We~~ the observation of different PL time decays in the TRPL spectra. At room temperature, the times were between 4 and 8 ns, for high and small angles, respectively. It is interpreted as the differences in the built-in electric field due to indium content change with miscut angle. Low defect concentration in our sample leads to high internal efficiency of light emission in our devices.

Fig. 1: Electroluminescence from two neighboring regions with different indium content on one of our devices. The change of wavelength can be clearly seen.

Our devices have one common anode contact, while separated cathode contacts were placed on each region with different indium incorporation (see Fig. 1), so that electroluminescence can be excited from each region separately or at the same time. We demonstrate, that our technique allows to obtain locally modified parameters and precisely determine wavelength of the emitted light, suitable for practical devices.