Structural investigation of the deep-green InGaN LEDs by transmission electron microscopy

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Abstract 250 words for technical review:

We study the influence of the quantum well (QW) thickness and composition on the luminous efficacy of the single QW deep-green light-emitting diodes (LEDs) grown by metal-organic vapor phase epitaxy. When the QW thickness increases from 1.7 nm to 3.0 nm the electroluminescence (EL) peak position shifts from 507 nm to 585 nm, while the EL peak intensity exhibits rather unexpected behavior: it increases with increase of the wavelength, reaches its maxima around 540 nm and then it begins to decrease monotonically.

The QW morphology, the In distribution and the strain relaxation in the active region were investigated by various methods of transmission electron microscope (TEM). The local chemical composition was determined by dark-field electron holography (DFEH) using Hitachi HF3300 in-situ interferometry microscope (I2TEM) allowing precise chemical composition measurement with spatial resolution up to 0.4 nm.

The TEM study showed that the thick QWs have a regular shape with abrupt interfaces and constant composition, while decrease of the QW growth time produces unintentional composition gradient inside the QW. Moreover an enhancement of the surface segregation effect resulting in the In incorporation into the GaN barrier was evidenced. The observed effect of the composition redistribution was investigated by TEM as a function of the In content of a QW. The factors governing In distribution during the growth of In-rich InGaN QWs are discussed.

Abstract 100 words for early release:

The external quantum efficiency (EQE) of the InGaN-based light-emitting diodes (LEDs) is known to decrease towards longer wavelength. We study influence of the growth parameters on the InGaN QW morphology and the In distribution in the active region of the long-wavelength yellow-green LEDs in relation with evolution of their EQE. We show that decrease of the quantum well (QW) growth time produces an unintentional composition gradient inside the QW and enhances In incorporation into the GaN barrier. The factors governing In distribution during the growth of In-rich InGaN QWs will be discussed.