Extreme InGaN growth conditions by plasma assisted molecular beam epitaxy

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The crucial challenge in high quantum efficiency nitride based devices like light emitting diodes (LEDs) or laser diodes is the growth of InGaN layers. In this work we study properties of InGaN layers grown by plasma assisted MBE (PAMBE) for very high nitrogen fluxes – 2.8 µm/h. These conditions are unusual for PAMBE technology since available high N flux is limited by e.g. MBE pumping speed to maintain enough high vcuum (less than 10^{-4} torr) during process. The high nitrogen flux prevents InGaN decomposition. This allows us to explore growth conditions of InGaN that were previously not achievable in PAMBE – growth at high temperatures. The InGaN layers were grown in In-rich conditions, with different Ga fluxes with constant N flux (2.8 um/h) and a very high growth temperature T_g=710 C.

The obtained results are analyzed within phenomenological model of InGaN growth assuming growth on nonequivalent atomic steps [1]. In Figure 1(c) the InGaN content as a function of Ga flux is shown according this model prediction. As the Ga flux is reduced, we observe saturation of In content due to the decomposition of InGaN (Nitrogen loss) - it is observed as stabilization of photoluminescence emission wavelength (around 430 nm). The behavior of emission wavelength for low (0.04 um/h) and high (2.5 um/h) Ga fluxes also follows model prediction of In content.

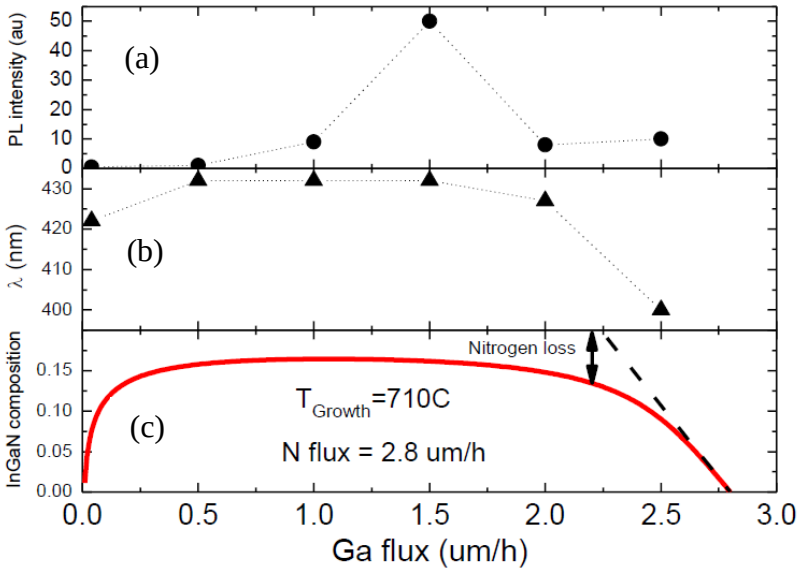

Fig. 1. The intensity of photoluminescence from InGaN layers (a), the wavelength (b) and the indium composition as a function of Ga flux (In content calculated from theoretical model [1]).

We found that the photoluminescence intensity strongly depends on the Ga flux (see Fig.1 (a)). It can be correlated with the surface morphology. We will discuss the photoluminescence efficiency, surface morphology and indium content of InGaN layers.

[1] H. Turski, M. Siekacz, Z.R. Wasilewski, M. Sawicka, S. Porowski, C. Skierbiszewski, Nonequivalent atomic step edges—Role of gallium and nitrogen atoms in the growth of InGaN layers, Journal of Crystal Growth 367 (2013) 115-121.