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# Optoelectronic structures with InAlN layers grown by MOVPE

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**Abstract.** The results of the some practical applications of InAlN layers in a device hetrostructures grown by MOVPE is presented. It is shown that use of InAlN allows not only create high-quality DBRs and HEMT structures, but also effectively modify properties of InAlN/GaN/InGaN light-emitting devices.

**Keywords:** Nitrides, MOVPE, DBR, HEMT.

**PACS:** 81.07.Ta, 81.05.Ea, 85.60.Jb, 81.15.Gh

## INTRODUCTION

In spite of the great progress in epitaxy of III-N compounds, most of devices developed during last 20 years were composed of GaN, AlGaN and InGaN layers, which are well technologically developed and investigated. Third ternary alloy in a GaN-AlN-InN system – an InAlN looks very promising but extremely complicated in point of view of synthesis. Use of InAlN in GaN-based optoelectronic structures gives additional degree of freedom, because InAlN depending on composition may be lattice-matched to GaN, tensile or compressively strained. This alloy can be useful for creation of different structures, including HEMT, RC LED and other optoelectronic devices.

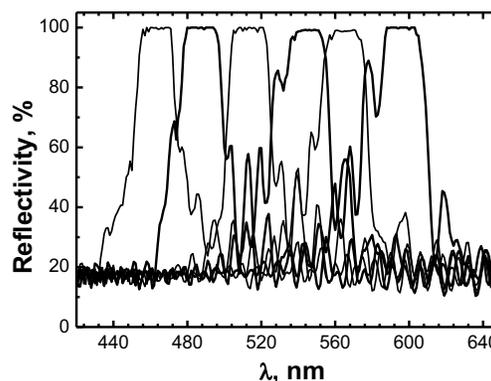
## EXPERIMENT

Epitaxial structures were grown on (0001) sapphire substrates using two MOVPE systems: standard AIX2000HT with Planetary Reactor and laboratory scale system with horizontal-flow inductively heated single-wafer reactor (strongly re-designed Epiquip VP-50RP). Details of growth can be found in [1].

### InAlN/GaN DBRs

Growth of InAlN is a complicated task itself, as growth conditions is a compromise of typical regimes

for InGaN and AlGaN growth. Details of InAlN growth optimisation can be found in [1], below presented some results of InAlN device application. Fine adjustment of growth parameters allows to growth thick enough  $\text{In}_{0.18}\text{Al}_{0.82}\text{N}$  layers lattice matched to GaN without phase separation and makes possible formation of high-quality DBRs with reflectivity exceeding 99%; Si doping of such structures results in conductive DBR making possible their use as n-type emitters in a RC LEDs with top metallic mirror.



**FIGURE 1.** Optical reflectance spectra of InAlN/GaN 57-pair DBRs with different stop-band positions.

## InAlN/AlN/GaN HEMTs

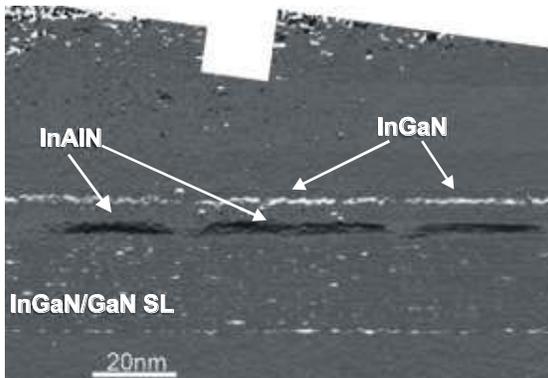
Use of InAlN in a 2D electron gas structures shifts the limits for carrier concentration that arise from lattice mismatch in AlGaN/GaN system [3]. For example, concentration can be easily increased from  $1.1 \cdot 10^{13} \text{ cm}^{-2}$  for GaN/AlN/Al<sub>0.3</sub>Ga<sub>0.7</sub>N to  $3.1 \cdot 10^{13} \text{ cm}^{-2}$  for lattice-matched structure GaN/AlN/In<sub>0.18</sub>Al<sub>0.82</sub>N. Moreover, use of InAlN allows compensating spontaneous polarization by piezoelectric field from *compressively* strained InAlN. Unfortunately, increase in In composition results in increased alloy scattering and decrease in mobility in spite of decreasing carrier concentration (Table 1).

**TABLE 1.** Parameters of GaN/AlN/InAlN HEMTs at RT.

In Content	n, cm <sup>-2</sup> * 10 <sup>13</sup>	μ, cm <sup>2</sup> /Vs
18-19	3.1	667
19-20	2.9	555
20-21	2.8	580
21-22	2.7	520

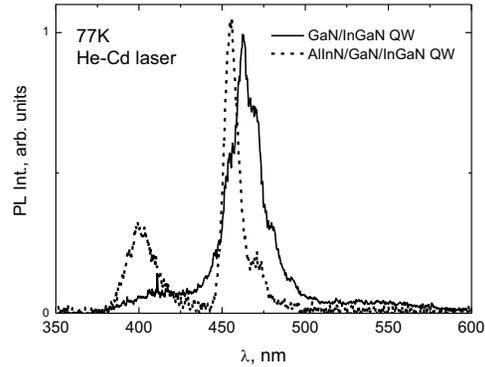
## InAlN/InGaN/GaN LEDs

Some specific results were obtained for GaN/InAlN/GaN/InGaN optical structures, where thin (1-18 nm) InAlN layer was grown in regimes close to phase separation. It was observed that growth of GaN/InAlN structure can result in formation of quantum dots with very high density ( $>2 \cdot 10^{11} \text{ cm}^{-2}$  by AFM data). High-resolution transmission electron microscopy (HRTEM) studies of 3 nm-thick InGaN quantum well grown over such bi-layer shows that InGaN grows predominantly over such tenth-nm islands (fig 2) in a strain-control mode.



**FIGURE 2.** HRTEM image of InGaN QW grown on InAlN/GaN bi-layer structure.

What is more interesting, these structures exhibit narrow luminescence in a blue spectral region in comparison with 3 nm-thick InGaN QW grown just on GaN layer (see fig.3), indicating strong suppression of phase separation of InGaN inside these 20-30 nm islands. Such structures, combining carrier localization on rather big islands preventing them from nonradiative recombination with “uniform QW”-like spectrum, can be very interesting for applications where narrow gain spectra is necessary, e.g. lasers or electrooptical modulators.



**FIGURE 3.** PL spectra of InGaN QW grown on GaN or on InAlN/GaN bi-layer structure.

## ACKNOWLEDGMENTS

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