APPLICATION NOTE

OUTSTANDING UNIFORMITIES FOR GaN QUANTUM WELLS

Introduction

GaN performances in the field of high power, high frequency devices, makes it a material of choice for wireless communications, networking, radar applications…

From this statement, active work has been achieved at RIBER's GaN Process Technology Center (PTC) in collaboration with CRHEA/CNRS. PTC's previous work demonstrated the high crystalline quality of AlGaN/GaN quantum well grown on GaN template substrate with state of the art results (see Application Note 608 26 N 02)
In this application note, we report the growth of GaN quantum well with very uniform properties- composition and electrical, outlining that Compact 21T GaN MBE system is a well-proven machine for GaN growth using ammonia source. High crystalline quality of AlGaN/GaN quantum well on 2" silicon substrate is also demonstrated.

Crystalline properties were investigated by low temperature photoluminescence (PL) technique performed with a 10 mW HeCd laser. Al composition uniformity was assess by PL spectra recorded from the center to the edge of the samples. Electrical properties were determined by Hall effect.

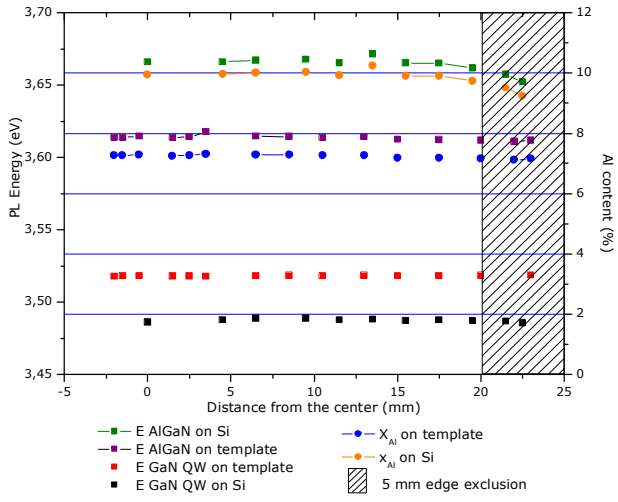


Figure 1: Photoluminescence
Energy position and Al content measured across the wafers

Results

Outstanding uniformity

To assign the homogeneity of the samples, photoluminescence data were recorded (figure 1) from the center to the edge of the wafers grown on GaN template and silicon substrates.

AlGaN/GaN quantum well grown on GaN template:
The energy position of the AlGaN peaks and correlated Al composition are very uniform across the sample grown on 2" (50 mm) GaN template, corresponding to a fluctuation of ± 1.4% of the Al content in AlGaN. Luminescence line width vary from 22.4 to 23.1 meV. GaN quantum well peak position is very uniform too, energy fluctuation is 0.8 meV and width varies from 9.6 to 10.2 meV.

AlGaN/GaN quantum well grown on Si substrate:
Structure grown on Si substrate exhibits larger fluctuations for AlGaN material, Al composition relative fluctuation is ± 2.5% excluding the standard 5mm periphery region. The AlGaN peak line varies from 20 to 24.6 meV. Quantum well energy peak variation is 3.2 meV, and the PL peak width varies from 16 to 18.1 meV.

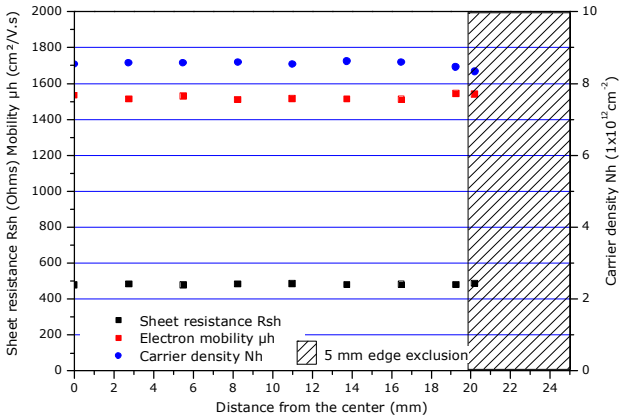
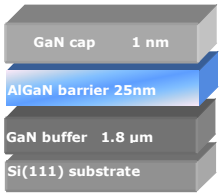


Figure 2: Sheet resistance, carrier density and electron mobility measured by Hall effect across the wafer for a HEMT grown on Si(111)



Typical HEMT structure

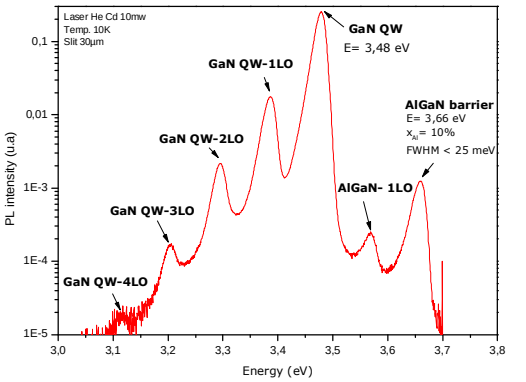


figure 3: 10 K Photoluminescence spectrum on a AlGaN/GaN SQW (10ML)

AlGaN/GaN QW grown on Si (111)

Noteworthy uniform electrical properties

Electrical properties were measured across the wafer by Hall effect at room temperature (figure 3). The structure grown on Si substrate, illustrated in figure 2, allowed to realize typical HEMT structures. Sheet resistance, electron mobility, and carrier density all exhibit fluctuation of ± 1% over the entire substrate.

Excellent crystalline quality

AlGaN/GaN quantum well on Si substrate:

The low excitation photoluminescence measurements (figure 3) of the sample is dominated by an intense emission peak corresponding to the confined state of the GaN quantum well at E=3,48 eV, abide by four phonon replicas transitions. The emission peak setting for the AlGaN layer is at an energy of 3.66 eV corresponding to the target value of Al composition of 10%.

These results in accordance with the state of the art of AlGaN/GaN heterostructure grown on Si substrate, outline the excellent crystallinity of the sample, necessary to achieve high performances devices.

Conclusion

In summary, since the inauguration of the GaN Process Technology Center we have highlighted, using Compact 21T GaN research system, state of the art structural properties of AlGaN/GaN quantum wells grown on GaN template (see our previous application note) and on Silicon substrate, as well as remarkable uniformities on Silicon, ± 2.5% variation of Al composition and ± 1% fluctuation of electrical properties.

Within these preliminary successful GaN growth results, Compact 21T GaN is the MBE system for the III-N research environment.

Experimental set up

Epitaxial growths were carried out in the Compact 21T GaN MBE research system equipped with ABN 80 cc effusion cells for group III elements and as a nitrogen source and ammonia delivery module, HTI 63.

About GaN PTC

The GaN PTC at CRHEA Valbonne, allows customers and prospective users to test the Compact 21T GaN for growth of structures or target specific device properties to enhance and accelerate their process knowledge. Training courses may be tailored to meet individual requirements. Experience accumulated in advance of system delivery saves months of post-installation process development.

For more information please contact info@riber.com