

## APPLICATION NOTE

# FIRST THz LASER REALIZED IN A PRODUCTION MBE SYSTEM

## Introduction

Since the first demonstration of Quantum Cascade Laser (QCL) emitting in the mid-infrared frequency band, research activities have been aimed at pushing operation into the far-infrared and THz frequency bands (100 GHz – 10 THz). These types of lasers have huge potential for spectroscopy and imaging across the physical, biological and medical sciences, with various applications including medical and dental imaging, atmospheric sensing, process monitoring and diagnostic testing, astronomy, high-bandwidth communications, and condensed matter physics...

In this Application Note RIBER's As/P Process Technology Center (PTC) reports the realization of a THz laser emitting at 105  $\mu\text{m}$ , for the first time ever in a multiwafer MBE production system (13x2" platen).

Growths were performed at the As/P PTC with THALES Research & Technology scientists. Matériaux et Phénomènes Quantiques –MPQ– laboratory (Paris VII University) has conceived and characterised the lasers. Structural characterization and laser processing were carried out at THALES Research & Technology / Alcatel-Thales III-V Lab.

## Experimental

In this present work the quantum cascade lasers were grown on semi-insulating 2" GaAs substrates on 13x2" platens. The active region, taken from the literature [1], consisted of 90 times repeated 128 nm periods of AlGaAs/GaAs heterostructures. The active region is embedded between top and bottom 100 and 270 nm thick GaAs doped layers.

## Results

### High structural quality

The structural quality of the laser was measured using X-ray rocking curves. Figure 1 shows sharp satellites solved up to the 20<sup>th</sup> order and the good agreement between the experiment and simulation, illustrating the high structural quality of the grown material, in terms of layer thickness, composition and interfaces.

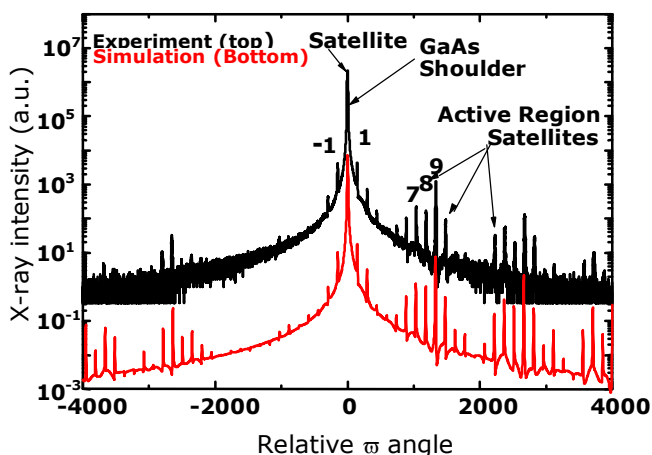
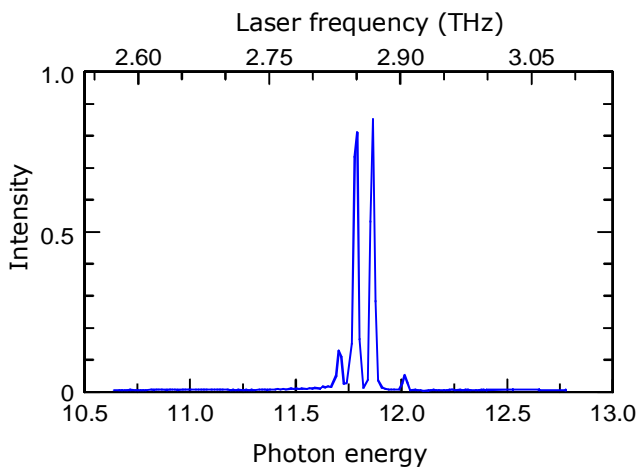


Figure 1 : X-ray rocking curve

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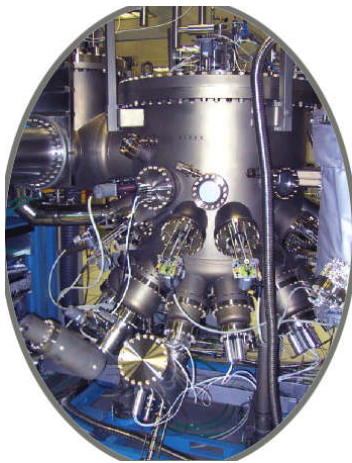
**Figure 2 : QCL lasing spectrum**

### Laser emission at 2.8 THz

Figure 2 displays the quantum cascade laser spectrum of a 2mm x 100 μm device. At 10K the spectrum shows emission at 2.8 THz which was observed up to 50K. This lasing emission for the time realized in a multiwafer production system is strongly related to the thicknesses of the grown layers, highlighting the excellent flux stability, reproducibility, control, and wafer temperature uniformity but also the excellent equipment reliability.

### Conclusion

The successful realization of such laser in a production MBE system demonstrates the high degree of accuracy, stability, and uniformity which is possible to get during the MBE growth process. Maximum operation of 50K measured represents the state of the art in terahertz Quantum Cascade Laser, at such frequency and using standard processing.



**MBE 49- reactor**

### System configuration

Growths were carried out in the MBE 49 multiwafer production MBE system equipped with ABN 700 cc, and ABI 1000 effusion cells for group III elements and as arsenic VAC 2000 and phosphorus KPC 1200 valved cracker cells.

### About As/P PTC

The As/P PTC at IEMN- Lille allows customer and prospective users to test the MBE 49 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.

[1]: S. Barbieri, J. Alton, H. E. Bere, J. Fowler, E. H. Linfield, D. A. Ritchie, "2.9 THz quantum cascade laser operating up to 70K in continuous wave" Appl. Phys. Lett. 85(10) 1674-1676 (2004)

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