Spatially Resolved Photoluminescence From Type II InAs/GaInSb W-shaped Quantum Wells In The Mid-infrared Spectral Range

Mateusz Dyksik[1], Marcin Motyka[1], Grzegorz Sęk[1], Jan Misiewicz[1]
Mathias Dallner[2], Robert Weih[2], Martin Kamp[2], Sven Höfling[2,3]
[1] Laboratory for Optical Spectroscopy of Nanostructures, Department of Experimental Physics, Wrocław University of Technology, Wrocław 50-370, Poland
[2] Technische Physik, University of Würzburg, Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Am Hubland, Würzburg D-97074, Germany
[3] School of Physics and Astronomy, University of St. Andrews, North Haugh, St. Andrews KY16 9SS, United Kingdom

***Abstract*—We performed a large-scale spatial mapping of photoluminescence from type II InAs/GaInSb W-shaped quantum wells in the mid infrared spectral range. Two types of structures based on InAs and GaSb substrate were investigated in order to test the growth uniformity.**

I. INTRODUCTION

During the last years mid-infrared semiconductor lasers have continuously increased their application range to include gas sensing for detection and control of the presence and concentration of environmentally-relevant gases like hydrocarbons, CO_2, SO_x and NH_3. One of the efficient solutions is the interband cascade laser (ICL) employing a broken gap material system to separately confine various carriers, and utilizing the interband transition in a cascade scheme. The natural candidate for the active region of ICLs is the so-called "W"-shaped type II quantum well made of InAs and GaInSb to confine electrons and holes, respectively. Such approach provides the effective band gap reduction and reduces the non-radiative processes i.e. Auger recombination.
Several approaches have been studied in order to spectrally cover the region of mid-infrared involving the ICL's substrate variation of GaSb and InAs. The GaSb based interband cascade lasers are able to cover the spectral range from 2 to 6 μm. In order to extend the emission to longer wavelengths the cladding region based on so-called index-guiding method (InAs/AlSb superlattices) has to be replaced due to too strong absorption in mid and far-infrared. This limitation may be overcome by an application of a plasmon-enhanced waveguide composed of highly doped indium arsenide layers. The plasmon-enhanced waveguide approach reduces cladding thickness that leads to enhanced heat dissipation and shorter growth time [1].

II. RESULTS

This work presents the results of uniformity investigations of full two-inch wafers containing five stages of type-II InAs/InGaSb W-shaped quantum wells grown on GaSb and InAs substrate, predicted for emission at 3 – 5 μm and 5 – 7 μm, respectively. The photoluminescence large scale spatial mapping has been performed in Fourier-based spectrometer (FTIR) with an evacuated external chamber for emission measurements in a step-scan mode [2]. InSb and MCT detectors have been used in order to cover the broad spectra range of interest. The laser was focused to the spot of 0.5 mm^2 on wafer, which was placed on an x-y stage, and which determines the spatial resolution.

The obtained results show high uniformity of the emitted wavelength (see fig. 1) deviating across the wafer's diameter within the range of 390±5 meV (3180±40 nm). This corresponds to the InAs layer thickness variation of below one monolayer. The full width at half maximum map also shows high regularity of 40±5 meV in the scale of the full wafer.

III. SUMMARY

It is the first time the spatial mapping of photoluminescence has been showed in the range of mid-infrared. The obtained results may be valuable in case of the MBE calibration and/or processing a fully operational device in manufacturing scale.

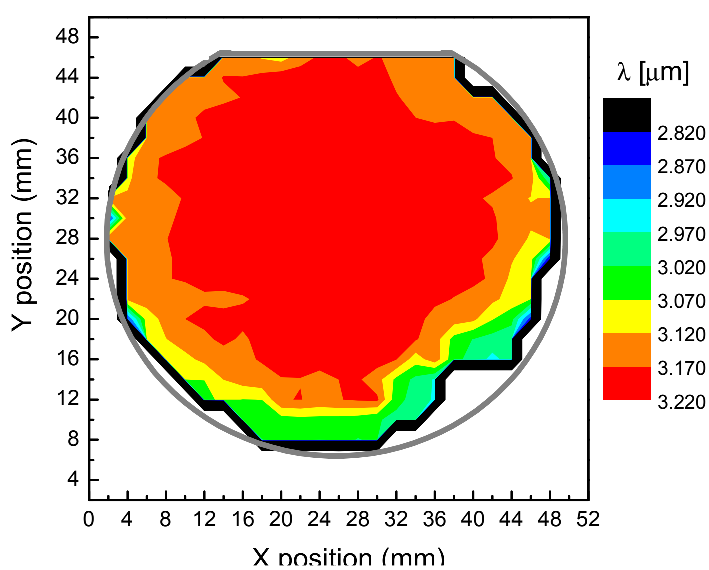

Fig.1. Spatially resolved photoluminescence map of the emission wavelength.

REFERENCES

[1]. Zhaobing Tian, Chen Chen, and Rui Q. Yang, "InAs-based Plasmon-waveguide Interband Cascade Lasers", *Proceedings of SPIE,* vol. 7616, pp. 76161B-76161B-9, 2010.
[2]. Marcin Motyka, Grzegorz Sęk, Jan Misiewicz, Adam Bauer, Matthias Dallner, Sven Hofling, and Alfred Forchel "Fourier Transformed Photoreflectance and Photoluminescence of Mid Infrared GaSb-Based Type II Quantum Wells", *Applied Physics Express*, vol. 2, pp. 126505, 2009.