Large-scale spatial mapping of photoluminescence from type II InAs/GaInSb W-shaped quantum wells in the mid-infared spectral range

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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].

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 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.

[1] Z. Tian et al., *Proc. of SPIE* **7616**, 76161B (2010)
[2] M. Motyka et al., *Appl. Phys. Express.* **2,** 126505 (2009)