Viduriniosios infraraudonosios srities VCSEL aktyviai terpei skirtų struktūrų su kvantinėmis duobėmis palyginimas

Comparative Study of Different Quantum Well Active Regions for Mid-IR VCSELS

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Nowadays mid-Infrared spectral region is very important for various applications, such as safety, thermal imaging, medical diagnostics, industrial process control, spectroscopy. Due to presence of strong absorption lines of various gasses in this region, such as CH_4, NO_2, CO_2, N_2O etc., mid-IR has a lot of potential for detection of these gasses [1]. Vertical Cavity Surface Emitting Lasers (VCSELs) seem to be the perfect choice for this application, however, in order to produce lasing at specific mid-IR wavelengths, proper active region has to be chosen. For wavelengths above 2.6 µm, GaSb technological platform has to be used, which faces a lot more challenges than GaAs or InP platforms typically used in shorter wavelength lasers [2].

The goal of this research was to find a proper active region design for long wavelength (above 3 micrometers) VCSELS. Three different designs were considered: type-I - InGaAsSb quantum wells (QWs) with AlGaSb barriers, type-II - W-shaped QWs with InAs electron confining layers and GaInSb hole confining layers, as well as type-II - M-shaped QWs.

Molecular Beam Epitaxy (MBE) was used for growth of the QW structures on unintentionally doped GaSb substrate. Optical microscopy was used to determine surface morphology and overall quality of grown films. Optical properties of the active region were studied by room temperature (RT) and 4K photoluminescence (PL) measurements. To imitate removal of the surface oxide before second epitaxial growth (two-step process is necessary for production of GaSb VCSEL), the as-grown samples were additionally annealed for 30 minutes at 500°C temperature and remeasured to determine the effect of annealing on QW optical properties.

It was found, that while type-I QWs do have highest PL intensities, they suffer from high post-annealing spectral shift. This undesirable shift would complicate technological processes in VCSEL production. Type-II M-shaped active region was expected to have superior luminescent properties [3], however, experimental characterisation also has shown significant post-annealing spectral shift (Fig. 1). Only type-II W-shaped QW structure had virtually no spectral shift as well as exhibited higher PL intensity. Thus, those structures were applied in production of MID-IR VCSEL.

Furthermore, various designs and growth conditions of QW structure, such as InAs layer thickness and growth temperature were optimized in order to tune the emission wavelength and achieve maximum PL intensity.

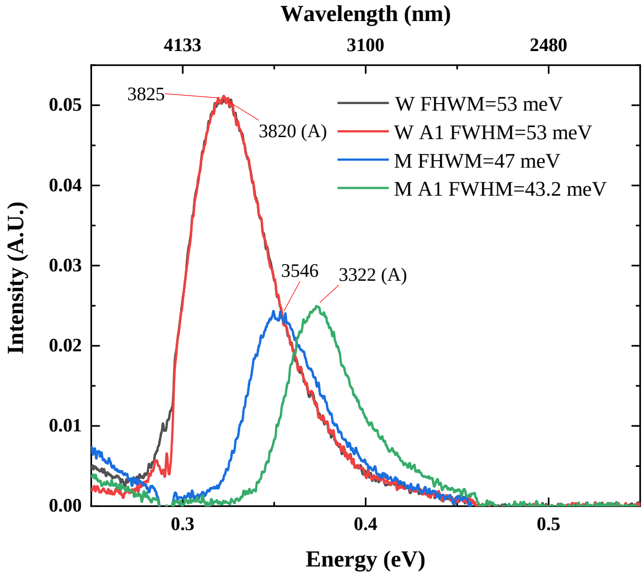

Fig. 1. Photoluminescence spectra of W- and M-shaped type-II quantum wells. Spectra labelled with (A) are attributed to annealed samples, while the other spectra are measured for as-grown samples.

Keywords: VCSEL, MID-IR, MBE, quantum well, photoluminescence.

References

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