InAs/GaInSb W-Quantum Well based Interband Cascade Lasers for Mid Infrared Emission

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Mid-infrared emitters, emitting in the 2-5μm wavelength range, offer a wide range of applications, including; atmospheric pollution monitoring, chemical process control, thermal imaging, and non-invasive medical diagnosis. To fully realise the potential of mid-infrared emitters in these applications a high-performance room temperature tuneable laser diode with low power consumption is required. Interband Cascade Lasers (ICLs) offer the potential for low threshold current densities and as such low-power while being able to generate continuous wave (CW) high optical power emission at room temperature [1]. W-Quantum Well (WQW) active regions offer great flexibility in band-structure engineering through modifying each QW individually. This provides a two-dimensional density of states for both electrons and holes (high differential gain), high wavefunction overlap despite their type-II band alignment (high gain) and a reduction in Auger recombination. Through combining an ICL with a WQW active region to produce an Interband-Cascade W-Quantum Well Laser (ICWQWL) high-performance room temperature laser diode has been achieved [2].

This work will present details on the growth and characterisation of ICWQWLs grown via molecular beam epitaxy (MBE) at Lancaster University. The WQW consists of InAs electron confinement wells and GaInSb hole confinement wells in a InAs/GaInSb/InAs configuration, which can achieve tuneable emission in the 3.6μm range close to room temperature [3]. To achieve electron injection and collection InAs/AlSb and AlSb/GaSb superlattices were used respectively. A series of samples were first produced utilizing these WQW, injection, and collection layers, to assess material quality via X-ray diffraction (XRD) measurements and lower temperature photoluminescence (PL). Device fabrication was then performed in Lancaster University's Quantum Technology Centre (QTC) using standard cleanroom processing techniques yielding Fabry-Perot ridge contact laser devices with cavity lengths of 1mm ridge widths of 10, 20, and 50μm. Initial 1mm cavity length 10 & 20μm ridge width laser devices yielded threshold currents of 576 & 580mA and peak emission wavelengths of 3.56 & 3.60μm respectively at room temperature.

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[2] C. L. Canedy, W. W. Bewley, J. R. Lindle, I. Vurgaftman, C. S. Kim, M. Kim and J. R. Meyer, "High-power continuous-wave midinfrared type-II "W" diode lasers," *Applied Physics Letters,* no. 211105, p. 86, 2005.

[3] G. K. Veerabathran, S. Sprengel, A. Andrejew and M. -C. Amann, "Room-temperature certical-cavity surface-emitting lasers at 4μm with GaSb-based type-II quantum wells," *Applied Physics Letters,* no. 071104, p. 110, 2017.

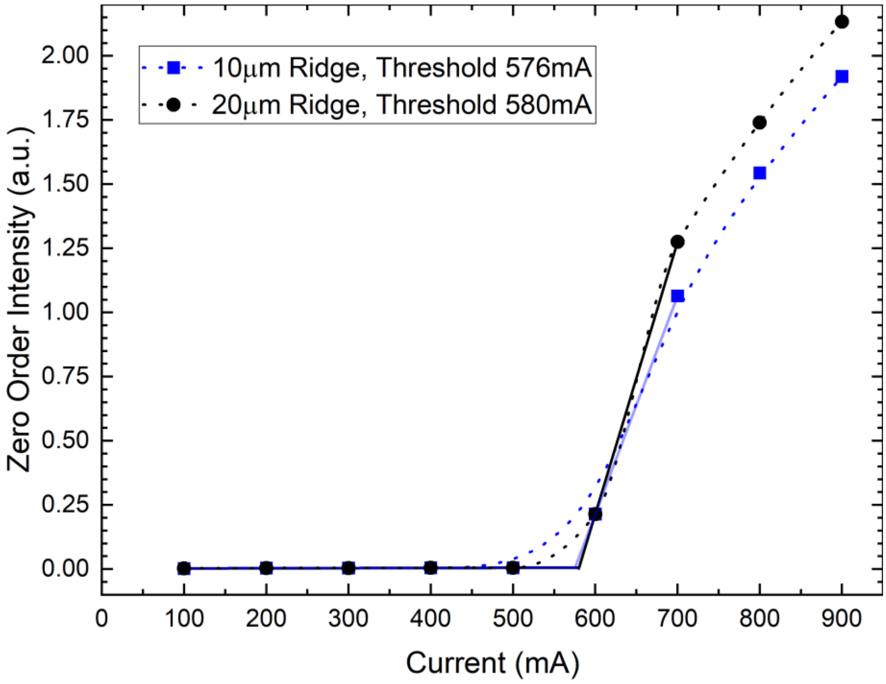

Figure 1: Room temperature current-Intensity characteristics of 1mm cavity length Fabry-Perot laser with 10 & 20µm ridge contact.

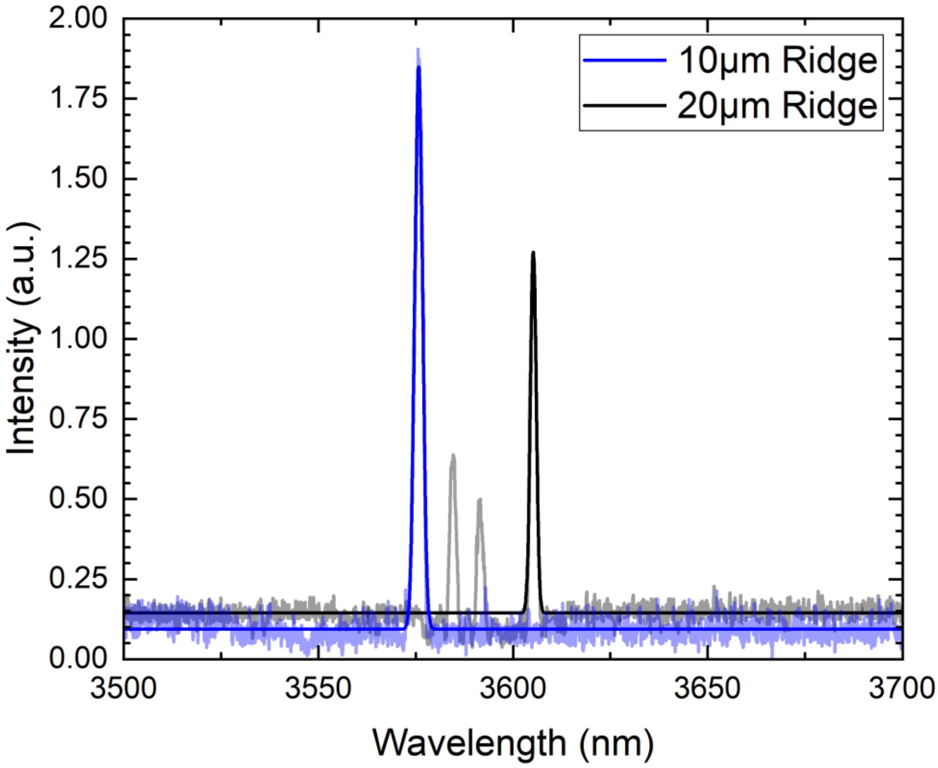

Figure 2: Room temperature electroluminescence (EL) spectra of 1mm cavity length Fabry-Perot laser with 10 & 20µm ridge contact under 600mA drive current 1% duty cycle.