

Final Report Summary Fabrication of QCL Lasers



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Background

The Quantum Cascade Laser (QCL) is a semiconductor device with unparalleled performance, wavelength agility and functionality across a large fraction of the mid IR spectrum (4-12 μ m). The emitted radiation is generated by injected electrons undergoing transitions between states confined within the conduction band of semiconductor quantum wells. The unique benefit of the unipolar nature of the device is that each injected electrons may be "recycled" through a number of active periods, to generate typically tens of IR photons. The wavelength of these emitted photons can be controlled by varying the widths of the quantum wells in the active region, to change the energy separation of the confined electron states.

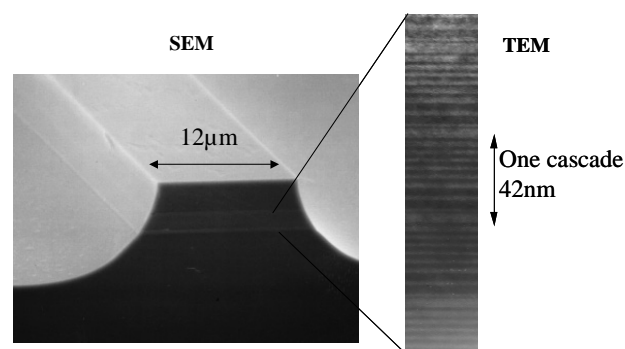
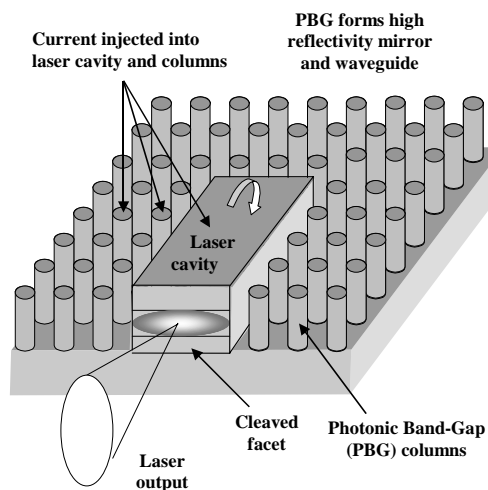


Figure 1 – Electron microscope images of a QCL laser



The operating characteristics of a QCL could be drastically improved by integration with a photonic bandgap (PBG) structure in order to produce a high finesse cavity to confine the laser optical mode. Researchers at Glasgow University Department of Electrical Engineering have an extensive track record in quantum cascade laser technology going back to 1998 when we were the first group outside the US to produce a quantum cascade laser, subsequently we have worked on PBG quantum cascade lasers in a bid to make more compact single frequency lasers with reduced current threshold.

Considerable progress has been made with a AlGaAs/GaAs QCL based laser, given this material system is compatible with Glasgows current etch technology. Of much more commercial interest is InP based QCL, but this requires the kind of technology available at CST, an Inductively Coupled Plasma (ICP) etch process.

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Scope of project

CST is interested in developing a fabrication process for high quality QCL lasers, and so initiated a collaboration with Glasgow to investigate the feasibility of transferring the PBG technology to an InP device platform. A critical factor in the technology is the ability to deep etch the PBG structure with sufficient quality.

Glasgow designed a PBG structure, fabricated a high precision photolithography mask via electron beam writing the pattern to a quartz plate, and then transferred this pattern to an InP based epi-wafer structure as a hard mask. CST have been carrying out etch trials on the structure in order to investigate the feasibility of the current ICP etch recipes for use in such technology.

Results

The PBG design proved difficult to etch using a standard dielectric hard mask, given there was a tendency for the mask itself to be removed as a result of long etch times required. Hence a NiCr mask has been implemented as is undergoing further investigation at CST.

Ongoing work

As a result of the collaboration a proposal was submitted to the DTI Technology Program under the Next Generation Lasers theme. A collaboration of CST, Glasgow University, Sheffield, Cascade Ltd and Shell Global Solutions was formed in September 2005.

As a result £1M funding has been awarded to further develop the technology for Gas Sensing applications, and a three-year project starts in May 2006.

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