High beam quality QCLs provide protection for airport terminals with eye-safe laser systems that can detect the release of airborne chemical threats

EPSRC
Engineering and Physical Sciences Research Council

National Centre for III-V Technologies

Universities of Sheffield, Cambridge, Glasgow, Nottingham

Case Study - Quantum Cascade Lasers

Quantum Cascade Lasers (QCLs) are unipolar lasers based on intersubband transition in semiconductor superlattice structures. They are a highly effective means of achieving lasers with operation wavelengths in the mid-infrared spectrum (2-20 microns), and provide industry standards in these areas. Applications for lasers in this wavelength include gas sensing, healthcare monitoring, molecular spectroscopy, infrared imaging and atmospheric physics.

Challenge

Since their invention in 1994 development of QCLs has progressed worldwide, but they remain a difficult laser structure to fabricate. The principal challenge is in the atomic layer control of the thickness of the constituent superlattice layers. In addition, this accuracy has to be maintained uniformly over 50 to 100 layer periods in the laser - very different to that of a normal interband laser. The precise design of the structures is also challenging due to the strong need to understand and control the electrical and optical elements of the structure across each of the superlattice periods.

Solution

The National Centre has been developing QCL science and technology since 2003 and has attained world class expertise in this area. Key factors allowing the National Centre to have a leading position in research and technology are:

> Strong design capability through collaboration with the Department of Physics in Sheffield
> The availability of both MBE and MOCVD epitaxy methods
> The availability of a range of material for QCLs including novel compositions such as Antimonide based QCLs where we are world leaders.
> The availability of regrowth technology which allows room temperature and CW operation of QCLs
> Fabrication of novel device geometries to improve performance
> Supply of fully packaged devices

Notable achievements from the National Centre are:

> Multi-watt, room temperature operation of QCLs in the range 3.3-3.7μm, an important but challenging wavelength region
> DFB QCLs with peak output powers of 130mW/facet
> The first demonstration of QCLs by MOVPE. The lasers have state of the art performance in the range 4-16μm
> GaAs/AlGaAs QCLs with record low thresholds
> Provision of QCLs to commercial customers and integration into products

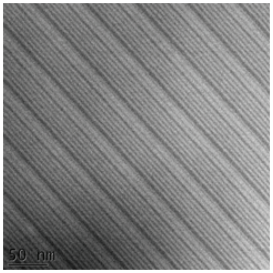
Conclusion

The National Centre has developed expertise and capability in QCLs that is available to researchers and industrial customers in the UK.

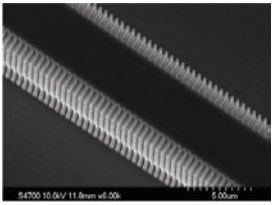
The National Centre continues to work with academic partners developing the technology further for both fundamental studies and applications.

New directions include improved performance at short wavelengths, development of THz lasers with similar structures, development of applications, fundamental physics including non-linear optics.

We welcome the opportunity to work with you in new areas of QCL and inter-subband devices built on this expertise.



Electron microscope image of multiple superlattice periods in a GaAs/AlGaAs Quantum Cascade laser grown at Sheffield



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