Development of single mode Quantum Cascade Lasers for Gas Sensing

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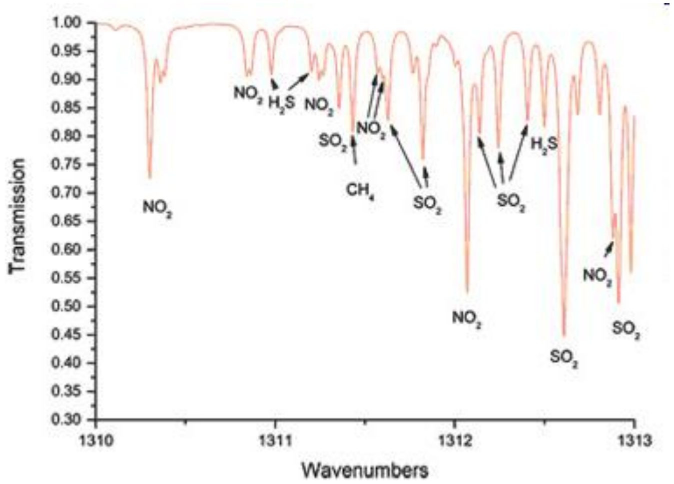
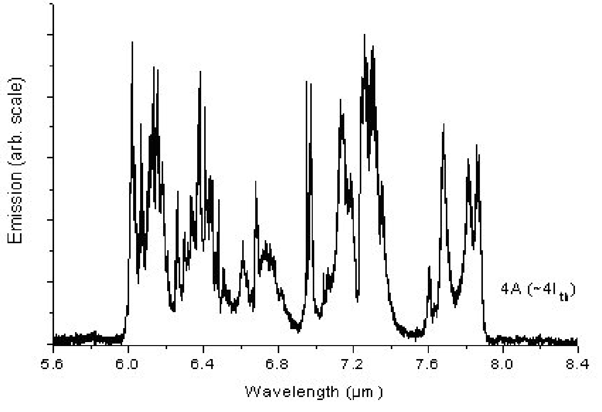
Mid-IR absorption in Gases

Gases have very strong and definite absorption lines in the mid-IR region

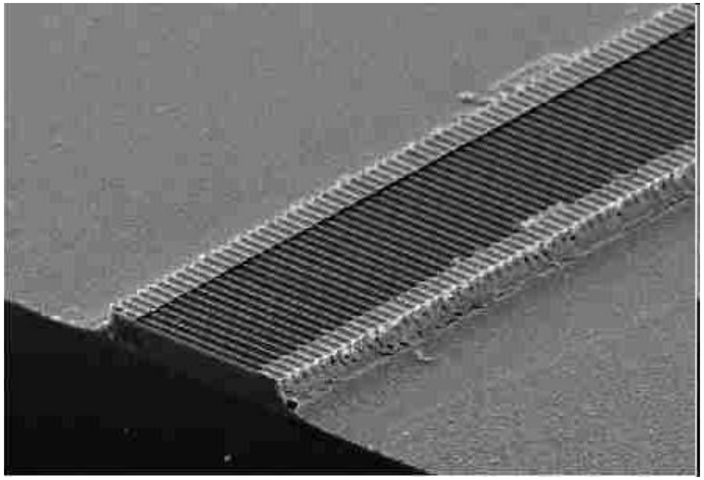


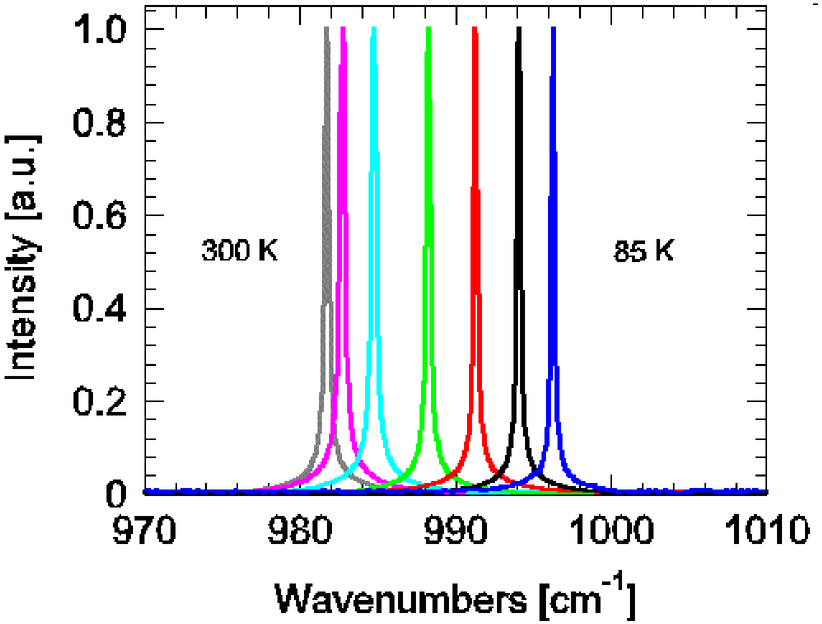
Quantum Cascade Lasers (QCLs) provide emission over this wavelength range
However QCL emission is typically broad meaning that any absorption cannot be attributed to one specific gas



Controlling the emission line

By introducing a periodic grating on top of the laser, what is known as a Distributed Feedback Laser (DFB) is formed.





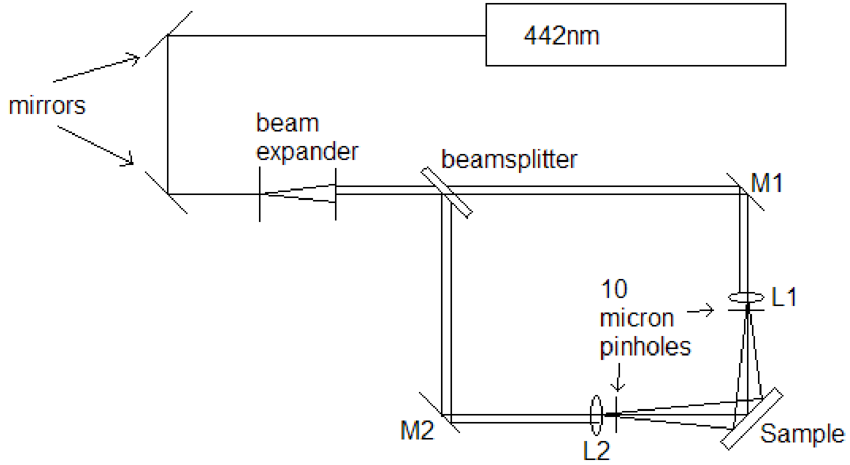
This has a very narrow emission line (determined by the period of the grating) which can be tuned by the temperature the laser is operated at and the current flowing through it.

Therefore by controlling the emission line Specific gases can be tested for by monitoring The absorption of that line

Interference Lithography

We have developed an interference lithography set-up to form grating patterns on laser material. This uses the blue emission line from a HeCd laser this is split into two paths that are then positioned onto of each other, forming an interference pattern.

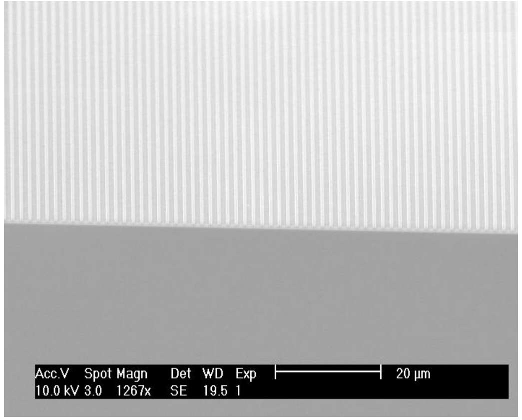
The grating is formed by coating the laser in a photosensitive material which is then exposed to the interference pattern and transferred to the photosensitive material. This can then be etched in acids to form this pattern onto the laser.

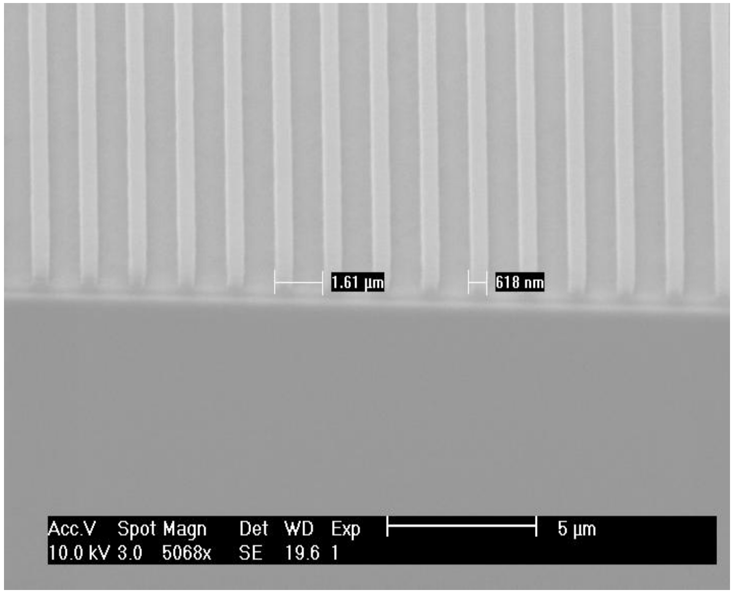


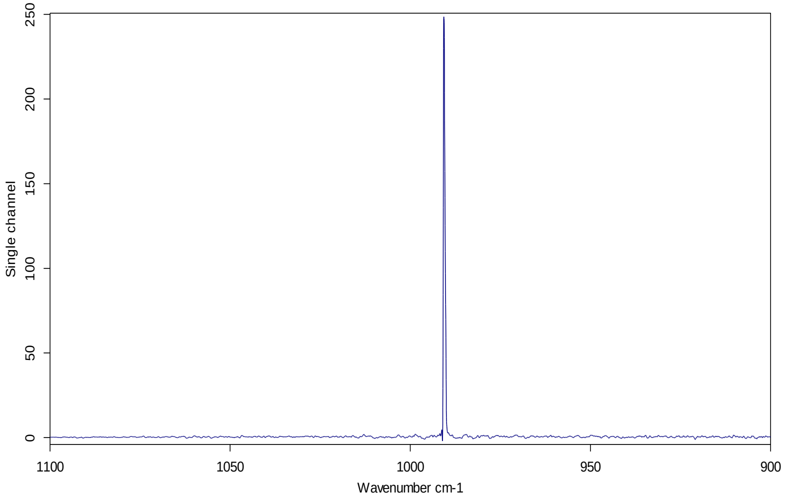
The period of the grating (and hence the emission wavelength) is governed by the angle at which the two laser paths meet.

Formation of Gratings

We have been able to form good quality gratings using this technique







Leading to single mode laser output, targeted
For the detection of Ammonia.

Reproducibility

Very high yields of single mode devices were made using interference lithography.
60% of the 1.5mm long devices were within 0.2% of the central wavelength