Room Temperature Lasing of Electrically Pumped Quantum Cascade Micro-Cylinders

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We investigated the lasing properties of micro-cylinders that were processed into a quantum cascade heterostructure. For close-to-circular micro-cavities, mirror losses are small because the light travels by total internal reflection close to the perimeter of the disk. Compared to ridge geometries, the reduced optical losses result in a decreased lasing threshold. Quantum cascade lasers (QCLs) – semiconductor heterostructure devices with several tens of photon-emitting cascades – are particularly suited for the microresonator geometry. Non-radiative surface recombination of electrons and holes does not occur in the unipolar QCLs, and small-scale surface roughness affects the QCLs with their relatively long emission wavelength of about 10 μm very little.

We compare the lasing performance of micro-cylinders with conventional Fabry-Perot (FP) resonators as well as with distributed feedback (DFB) lasers, all processed from the same GaAs/AlGaAs superlattice structure. We find that the threshold at low temperatures for both micro-cylinder and DFB lasers is decreased by a factor of about 2 below that of the FP laser (Fig. 1). The reason for this is that the emission losses of the FP laser are higher and therefore the threshold is higher. The maximum operating temperatures of the micro-cylinder and the DFB lasers exceeds the maximum operating temperature of the FP laser by at least 50 °C, again a benefit from the reduced threshold.

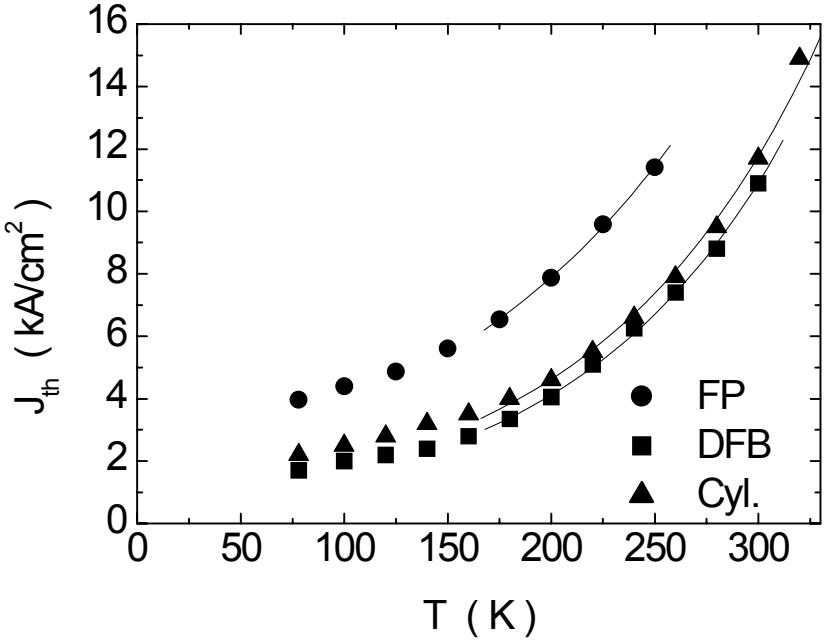

Fig. 1: Threshold current density as a function of temperature for different laser cavities (FP: Fabry Perot, DFB: distributed feedback, Cyl.: micro-cylinder) in pulsed mode operation.

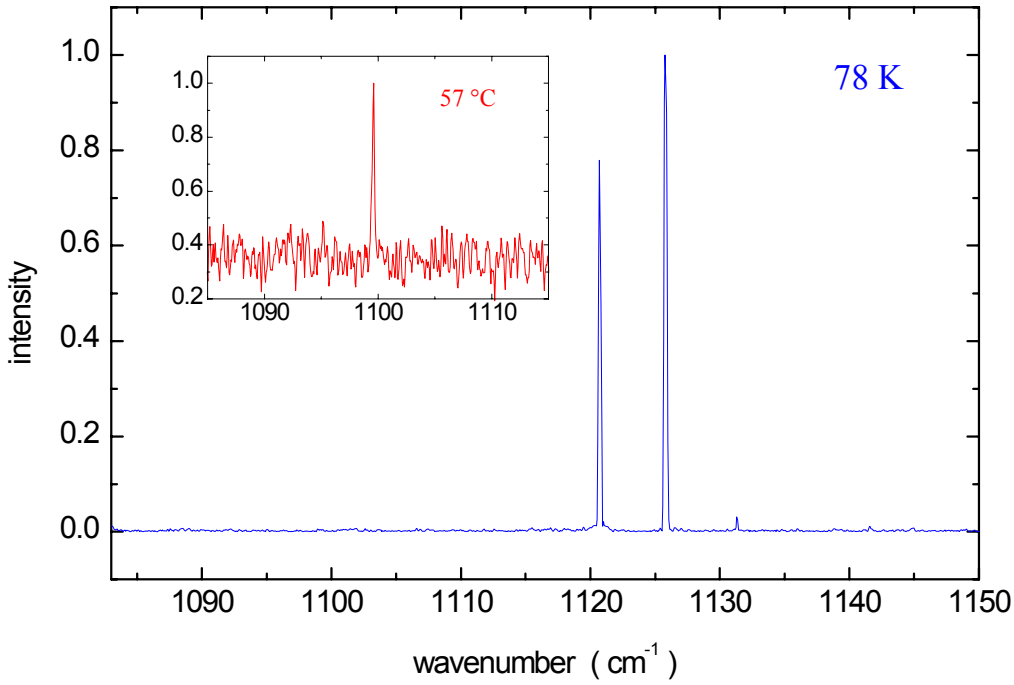

Fig. 2: Emission spectra of a micro-cylinder laser at cryogenic temperature (78 K) and at the highest working temperature (57 °C).

The maximum operating temperature of around 50 °C for micro-cylinder lasers significantly exceeds the previously reported maximum operating temperature for a micro-cylinder, –3 °C, which was obtained for an InP based quantum cascade laser.

Figure 2 shows the emission spectra of micro-cylinder lasers in pulsed mode operation. The spectra were measured with a Fourier transform infrared spectrometer.