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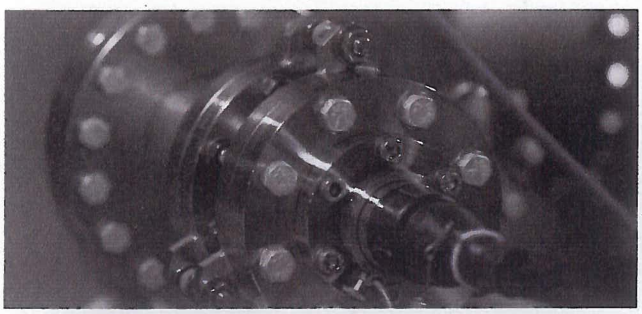

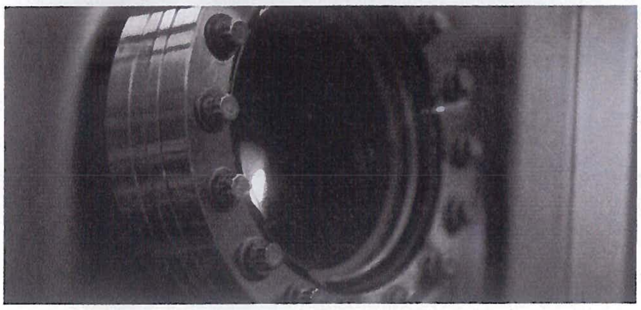

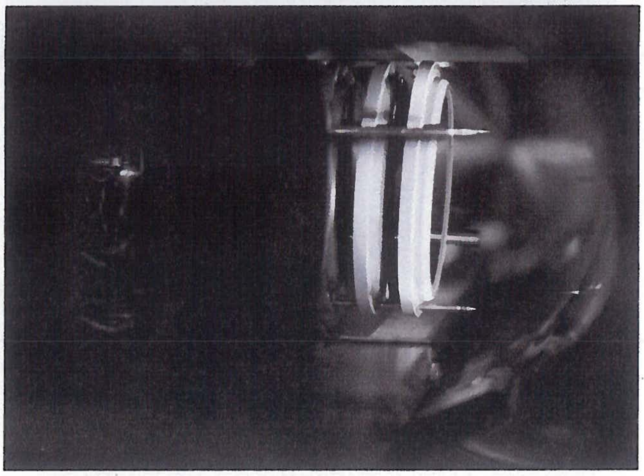

High Power THz Quantum Cascade Lasers

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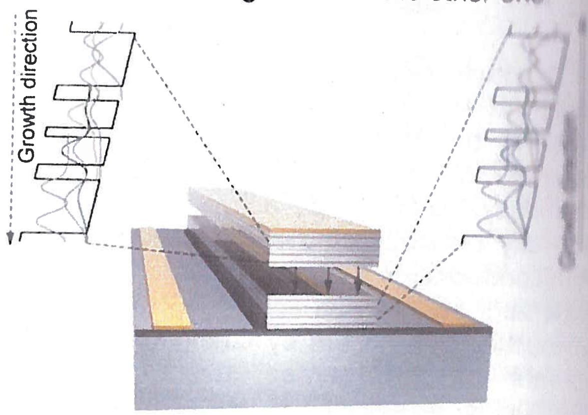
The terahertz (THz) spectral region is of particular interest for numerous applications relying on the unique properties of many materials at these frequencies. Quantum cascade lasers (QCLs) are compact, electrically driven sources, able to emit coherent radiation in this spectral region. One particular feature of THz QCLs is the high output power, which makes THz QCLs highly interesting candidates for future applications like remote sensing and imaging [1,2]. So far, the maximum operation temperature of these devices is limited to about 200 K, which necessitates cryogenic cooling for operation.

To achieve the highest peak output powers, so-called semi-insulating surface plasmon (SISP) waveguides are commonly used, where the mode is confined between a top metal layer and a semi-transparent, highly doped semiconductor layer on the bottom. One drawback of this technique is a comparably low maximum operation temperature, which can be attributed to the low confinement of the optical mode within the active region. To address this issue, we increased the number of cascades in the active region and thus also the waveguide thickness, which leads to an improved confinement of the optical mode within the active region. Furthermore, more light is generated due to an increased active region volume. Since the growth of the active region is typically performed by molecular beam epitaxy (MBE), fabricating thicker structures would require unreasonable long time. Thus, we make use of a direct wafer bonding technique to stack two equal active regions of regular thickness on top of each other [3].

In Fig. 1 the fabrication of a wafer bonded terahertz QCL with SISP waveguide is illustrated. The upper active region is flipped upside down and bonded on top of the lower one. For an applied bias voltage, he electrons move in growth direction in one sub-stack, and against it in the other one.



Thus, the active region needs to show the same operation characteristics in

Fig. 1 Illustration of a stacked actrive region with SISP waveguide.

both bias directions in terms of threshold current and gain spectrum. Previous experiments showed that a symmetric bandstructure alone would not lead to symmetric transport and performance behavior [4]. We thus had to compensate for growth-related asymmetries, which are identified to be due to dopant migration in the used GaAs/AlGaAs material system. The fabricated devices show a two-facet peak optical output power of 0.94 W at 5 K, and still more than 0.6 W at 70 K [5]. The device furthermore shows a comparably high maximum operation temperature of 122 K. In principle, even more active regions can be stacked on top of each other, which would further increase the output power, the confinement factor and thus the overall device performance.

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