High Power THz Quantum Cascade laser at ~ 3.1 THz

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***Abstract*— The development of quantum cascade laser at ~3.1 THz is reported. The material was designed with bound-to-continuum active region and grown by Veeco GEN-II solid source molecular beam epitaxy. Devices were processed using standard photolithography and wet chemical etching. Lasing is observed up to a heat-sink temperature of 110 K in pulsed mode with total light power above 1W at 10 K. A liquid nitrogen package is achieved.**

I. Introduction

QUANTUM cascade laser (QCL) is the most promising laser source in THz region today. Although this kind of source operates at low temperature generally, it behaves compact, coherent and high efficiency. Owing to these features, it can be used for secured communication, remote chemical sensing, bio-medical imaging, and astronomical spectroscopy. To this end, high power, low-consumption, and convenient THz quantum cascade laser s are desired. Nowadays, a practical way is to stably operate above liquid nitrogen temperature with high power above 100mW. To pursue the performance of high power, a bound-to-continuum active region (Fig.1) and a semi-insulating surface-plasmon waveguide is chosen in this study.

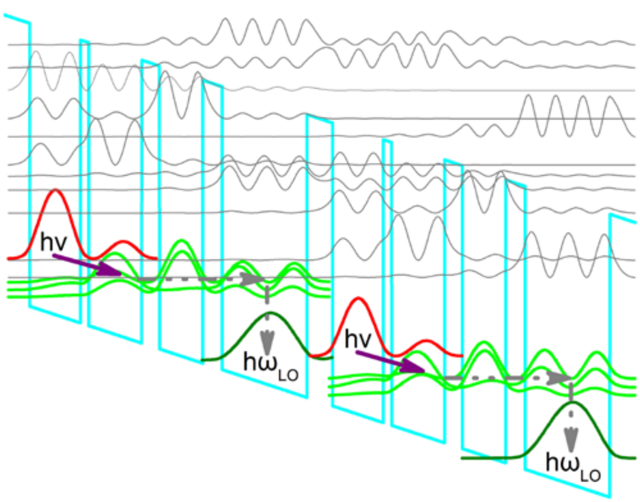

Fig. 1. Conduction band profile and the moduli squared of the most relevant wave functions calculated using a Schrödinger solver under a bias electric field of 8 kV/cm. The material system is $Al_{0.15}Ga_{0.85}As/GaAs$ and the conduction band offset of 0.135 eV is used.

A standard device process is used as reference [1]. A 420 μm ×3mm laser bar without high reflectivity (HR) coating on the rear facet is chosen for characterization. The measurement method used in this paper is same to reference [2]. For the output light power, two facets are considered

II. Results

Fig2. shows the L-I relationship of the THz quantum cascade laser at various heat-sink temperatures. A record high collected two-facet edge-emitting peak optical power of 1.05 W is demonstrated at 10K with ~3000 mA injection current. The device lased up to 110K with a peak output power of 42 mW. Moreover, a total high power of 330mW was obtained at a heat-sink temperature of 90K, which is an encouraging step towards a widely applicable solid-state terahertz source operating above liquid nitrogen temperature. The inset of Fig.2 shows the lasing spectra at a heat-sink temperature of 10 K. The central frequency is about 3.1 THz.

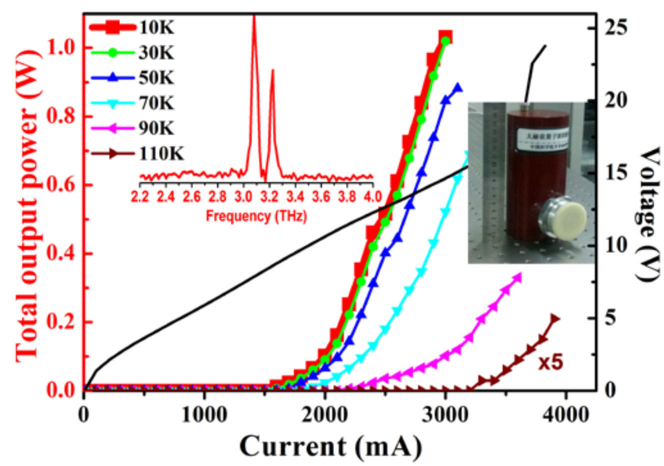

Fig. 2. Total light power versus current characteristics at various heat-sink temperatures measured using 2-μs pulses repeated at 5 kHz. The voltage versus current at 10 K is also shown. Spectrum from the same device at a heat-sink temperature of 10K is shown in the inset and also a THz-QCL with liquid nitrogen package.

III. Summary

We reported a THz quantum cascade laser based on the bound-to-continuum active region and the semi-insulating surface-plasmon waveguide. A high total light power above 1W at 10K and 300mW at 90K is obtained. There is performance repeatability for this kind of lasers. These devices exhibit a potential of higher performance by optimized fabrication processing, such as epitaxial-side mounting.

References

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