Phase locking and characterization of a 4.7 THz quantum cascade laser using a superlattice diode harmonic mixer

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***Abstract*— We have phase locked a 4.7 THz quantum cascade laser (QCL) to a microwave reference signal using a novel GaAs/AlAs super-lattice diode as a harmonic mixer operated at room temperature. The signal above the noise level is 20 dB, observed for a 0.4 GHz beat signal between the 24th harmonic of a 198.4 GHz reference source and the 4762 GHz signal of a QCL. A phase-locking loop with 10 MHz bandwidth allows locking of 80% QCL emission power to the reference source. Using the beat signal, we have also characterized both the power and frequency of the QCL versus the bias voltage with a high accuracy.**

***Keywords*— harmonic mixer, superlattice, phase locking, quantum cascade laser.**

I. Introduction

During past decades, considerable progress has been made in development of quantum cascade lasers (QCLs) by increasing output power and improving the far-field beam pattern, making QCLs an effective and reliable technology for THz local oscillators (LOs). Phase-locking of QCLs is necessary for spectroscopic applications.

II. Results

For down conversion of the QCL signal to a microwave frequency we have used a harmonic mixer based on GaAs/AlAs superlattice diode [1,2], shown in figure 1. The current superlattice has 6 periods, each period includes GaAs of 18 monolayers and AlAs of 4 monolayers and it is homogeneously doped with Si of 2 x 10^{18} cm^{-3}. By reducing number of periods by a factor of three comparing to the previously used diodes, the conversion efficiency was improved by more than 10 dB.

The phase-locking has been demonstrated for two QCLs. The first laser was operated in a liquid He cryostat and radiated only about 0.07 mW at 4.72 THz. The second one was much more powerful, providing power of about 0.8 mW at 4.76 THz while operating in a Stirling cooler around 60K. The examples of the down-converted phase-locked spectra are shown in Figure 2 and 3.

Additionally, we will present measurements to characterize the frequency of the QCLs as a function of bias voltage using the harmonic mixer down conversion scheme.

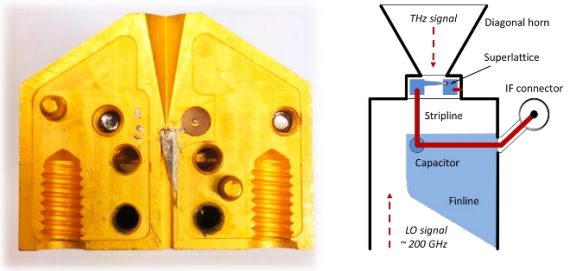

Fig. 1. Photo of the harmonic mixer (left) and its schematic illustration (right).

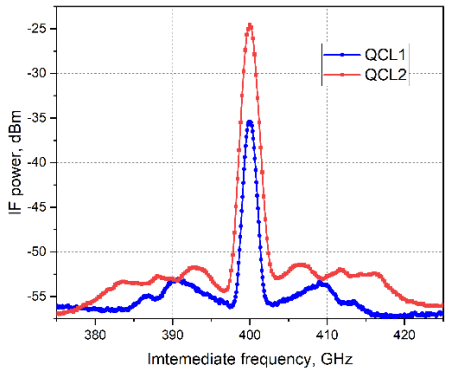

Fig. 2. Down-converted spectra of the two phase-locked QCLs at 400 MHz, measured by a spectrum analyzer with an RBW of 1 MHz.

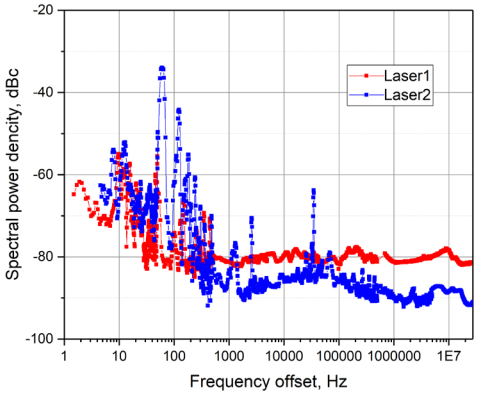

Fig. 3. Measured phase noise of the two phase-locked QCLs.

References

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