Phase-locking of a 4.7 THz quantum cascade lasers based on a harmonic super-lattice mixer

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For heterodyne spectroscopy in the super-THz (~2-6 THz) there are currently few solid state local oscillator (LO) sources available. Since the introduction of the first THz quantum cascade laser[1] (QCL) much progress has been made in pushing QCLs to higher frequencies, increasingoutput power and improving the far-field beam profile making the QCL increasingly well suited as a heterodyne LO. QCLs have been demonstrated in THz heterodyne receivers at frequencies up to 4.75 THz[2]where the astronomically significant neutral atomic oxygen [OI] line is situated.

Since QCLs are not inherently frequency stable, some external frequency stabilization or phase locking must be applied.We previously reported on the phase locking of a 3.4 THz QCL[3]based on a superlattice harmonic mixer[4]. Using a similar technique, we can now report on a successful phase locking experiment with a 4.7 THz QCL by using a superlattice harmonic mixer cooled to 10 K. In this configuration, both the harmonic mixer and the QCL are mounted together in a common cryostat and at a common temperature. The QCL used is a single mode, 3rd order distributed feedback laser. A beat signal of 400 MHz between the QCL and a reference is generated by the super-lattice harmonic mixer, where the QCL signal is mixed with the 24th harmonic of the 198 GHz input signal. The latter is the local oscillator signal for the harmonic mixer which is injected through a window in the cryostat from an external solid state source.

Phase locking is observed from a beat signal that ismore than 25 dB above the noise level for a 30 kHz resolution bandwidth of the spectrum analyzer. This system also allows for a detailed characterization of the QCL tuning coefficient and linewidth versus applied bias voltage down to low QLC output power.

References

1. R. Köhler, A. Tredicucci, F. Beltram, H. E. Beere, E. H. Linfield, A. G. Davies, D. A. Ritchie, R. C. Iotti, and F. Rossi, Nature 417, 156 (2002).
2. J. L. Kloosterman, D. J. Hayton, Y. Ren, T. Y. Kao, J. N. Hovenier, J. R. Gao, T. M. Klapwijk, Q. Hu, C. K. Walker, and J. L. Reno, Appl. Phys. Lett. 102, 011123 (2013).
3. D. J. Hayton, A. Khudchenko, D. G. Pavelyev, J. N. Hovenier, A. Baryshev, J. R. Gao, T. Y. Kao, Q. Hu, J. L. Reno, and V. Vaks, Appl. Phys. Lett. 103, 051115 (2013).
4. D. G. Paveliev, Y. I. Koshurinov, A. S. Ivanov, A. N. Panin, V. L. Vax, V. I. Gavrilenko, A. V. Antonov, V. M. Ustinov, and A. E. Zhukov, Semiconductors 46, 125 (2012).