Study and improvement of THz quantum cascade laser beam-pattern for different waveguides configurations.

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Abstract: We present a study of the emission properties for different THz laser structures such as Fabry-Perot single and double metal cavities, first order single plasmon DFB and double metal surface emitting photonic crystals, together with practical techniques for their improvement.

In the recent years THz Quantum cascade lasers (QCL) are emerging as new useful laser sources in the THz spectral region [1]. Their principal expected applications are as local oscillators for heterodyne receivers and as sources for spectroscopy and imaging [2,3,4]. In order to develop the practical use of THz QCL, output power and beam pattern of these structures have still to be improved. We present a study of the emission properties for different THz laser structures such as Fabry-Perot single and double metal cavities, first order single plasmon DFB and surface emitting double-metal photonic crystals. We also show different practical techniques to improve both optical output power and beam patterns. In particular in figure 1 and 2 are presented results obtained for double metal Fabry-Perot cavities using pyramidal structures inspired to the so-called microwave horn antennas [5]. Using semi-insulating (SI) gold coated gallium arsenide, mechanically polished at 45 degree and glued at the output of our lasers, we lengthened metal layers of the waveguide guiding the light emission up to the free space[see inset figure 1]. Using these structures we observe an optical power enhancement up to ten times and a quasi circular laser beam pattern. In figure 3 we show also improvements obtained for single plasmon laser beam pattern: decoupling all the parasitic radiation from the laser emission, we succeed to remove the interference rings from the beam pattern.

1 R. Köhler, A. Tredicucci, F. Beltram, H. Beere, E. Linfield, A. Davies, D.Ritchie, R. Iotti, and F. Rossi, “Terahertz semiconductor-heterostructure laser” Nature, 417, 156 (2002).

2 P.H Siegel, “Terahertz technology”, IEEE Trans. Microwave Theory Tech. 50, 910 (2002).

3. H.W. Hübers, S.G. Pavlov, A.D. Semenov, R. Köhler, L. Mahler, A. Tredicucci, H.E. Beere, D.A. Ritchie and E.H. Linfield, “Terahertz quantum cascade laser as local oscillator in a heterodyne receiver.” Opt. Express 13, 5890 (2005).

4. D.R. Chamberlin, P.R. Robrish, W.R. Trutna, G. Scalari, M. Giovannini, L. Ajili, J. Faist , “Imaging at 3.4 THz with a quantum-cascade laser”, Appl. Optics 44 (1), 121-125 (2005).

5. M.I. Amanti, M. Fischer, C. Walther, G. Scalari and J.Faist, “Horn antennas for THz quantum cascade lasers”, submitted to Electronics Letters.

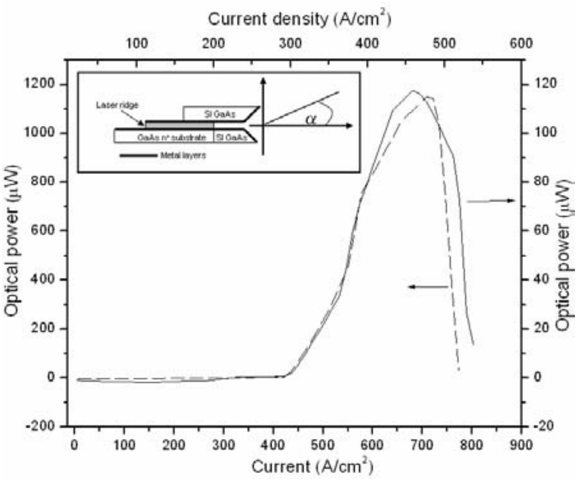

Fig. 1 CW Optical power against drive current for double metal Fabry-Perot laser with horn structure (dashed line) and without (continuous line) at 10 K. Inset: schematic of laser with horn structures and definition of the angle α.

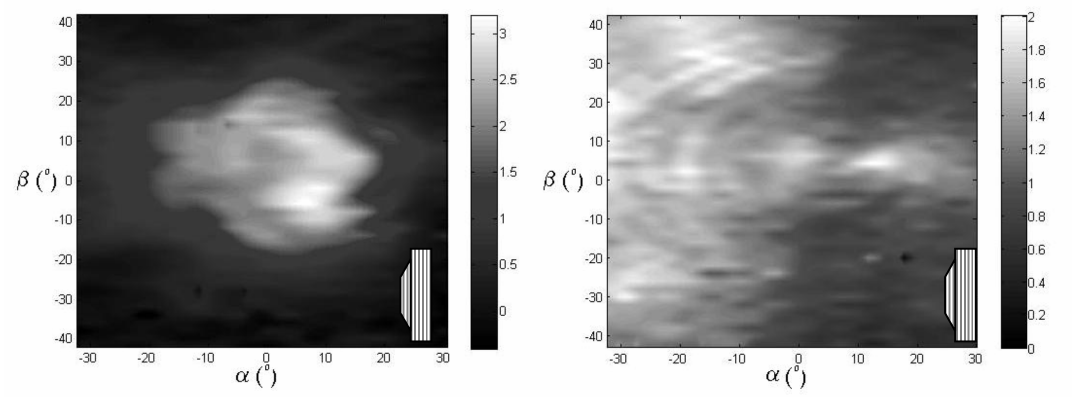

Fig. 2 Beam pattern of light emission from double metal Fabry-Perot facet at 10 K, for laser with horn structure (left) and without (right).

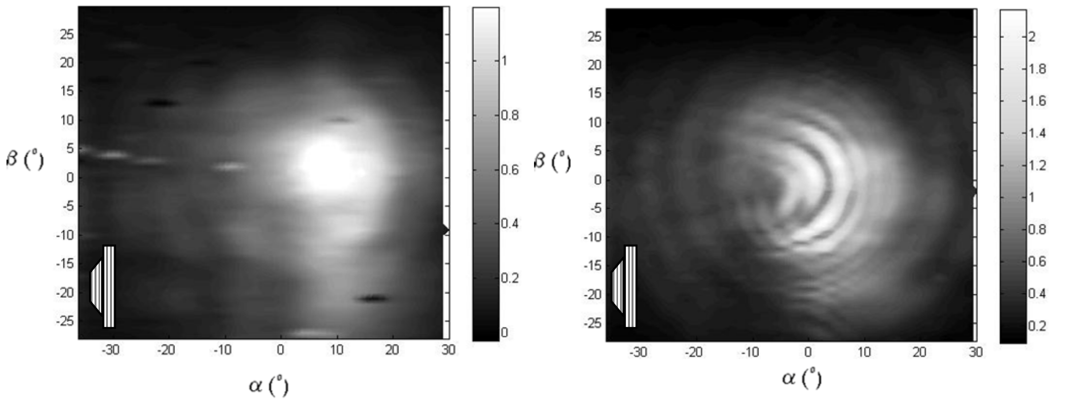

Fig. 3 Beam pattern of light emission from single plasmon Fabry-Perot facet at 10 K, for laser decoupled (left) and not (right) from parasitic radiation.