High Power Quantum Cascade Laser Arrays

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TECHNICAL ABSTRACT

One of the crucial points to have a high power quantum cascade laser (QCL) is to manage correctly the thermal effects. There are two ways of improving the efficiency of the laser: design a better active zone less sensitive to the elevation of the temperature as it is be done in [6] or decrease the thermal resistance. We will introduce a new way to improve thermal dissipation by using μ-stripes array technology (see fig 1). These buried arrays are very appealing because they offer both lateral dissipation enhancement and beam quality control in large active region lasers.

Figure 1. SEM images of technological process steps. (a) After ICP dry etching. (b) After InP:Fe regrowth. (c) Final step, after upper cladding InP:Si regrowth and metallization.

We will show by standard finite element simulations that enhancement of the thermal resistance is very promising for this type of technology (see fig 2). We have obtained within this technology experimental thermal resistances of mounted devices down of 2 K/W. Comparison between experimental and theoretical results show excellent agreement allows us to make prediction on the possibility of this technology. Thermal resistance decreases with both number and...
width of emitters. Furthermore we have also shown in previous work phase-locking provided by evanescent coupling between adjacent ridges and single-mode emission up to 32 emitters.

We want to combine the µ-stripes approach with an improved design of the active region. We will show how we can predict the $T_0$ of a given design with a semi-classical Boltzmann-like model [1-3] (see fig 3). We assume thermalized carrier distribution in each sub-band, so that only the global populations of the sub bands enter in balance rate equations. We can take into account various types of scattering mechanisms, including stimulated emission and absorption of photons. The laser cavity is introduced by solving self-consistently the population of the electrons and the density of photons in the cavity. We have extended this model to take into account tunneling transport across the injection barrier as in [4]. We will show the comparison of this two approaches on the prediction of the $T_0$ of the QCLs. We will also show how this extension affects the prediction of the electronic temperature [5].

Fig2: Evolution of the thermal resistance with the total width of the active region for µ-stripe (blue and green) and standard broad laser (red). Comparison between experiment (point) and simulation (continuous lines) show excellent agreement

Fig 3: Evolution of threshold current with temperature from simulation (red cross) and fit with an exponential law (blue line). From fit of theoretical point we find a $T_0$ of 381 to be compared with 383 from experiment (design of ref [6])


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