Experimental and theoretical study of intersubband electroluminescent diodes based on different materiel systems

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***Abstract*—We performed a comparison between the quantum efficiencies of two electroluminescent quantum cascade diodes based on GaAs and InP material systems.**

***Index Terms*— Infrared measurements, Light-emitting diodes, Optoelectronic devices**

Quantum cascade lasers emitting in the mid-infrared wavelength range are commonly realised using four material systems: InAs/AlSb//InAs, GaAs/AlGaAs//GaAs, GaInAs/Al(Ga)AsSb//InP and GaInAs/AlInAs//InP. The performances of the lasers based on these material systems are very different [1,2,3,4]. The motivation for this work is to understand if these differences are intrinsic of the material system properties.

In this work we compare the electrical and optical characteristics of two quantum cascade electroluminescent diodes, both emitting at 10 µm. They are based, respectively, on GaAs/AlGaAs and InAs/AlSb material systems. In order to make sure that the only differences between these diodes come from the material properties (effective mass, LO-phonon energy) we designed for both structures a simple active region, in which the radiative transition takes place in a single quantum well.

The insets of figures 1 and 2 show the light – current (L(I)) and voltage – current (V(I)) characteristics of the InAs and GaAs based diodes measured at a temperature of 78 K. The luminescence shows a well-defined linear dependence with the injected current, showing that the quantum efficiency, at a fixed temperature, is constant with the injected current.

The electroluminescence spectra, measured at 78K, are shown in figs. 1 and 2 (respectively for InAs and GaAs based diodes). They both show a single peak: for the GaAs diode it is centred at 120 meV with a FWHM of 9 meV, while for the InAs diode it is centred at 127 meV (FWHM=9 meV).

The quantum efficiency is proportional to the ratio between the non-radiative and the spontaneous emission lifetime.

As the collection efficiency is the same for the two sets of measurements, we compared the ratio of the experimental quantum efficiencies with the calculated one. The energy dependent electron effective mass is calculated through a three band k.p model [sirtori, non-parabolicity]. The parameters used for the calculation of the effective mass, as well as the LO-phonon energy and the interface roughness parameters, have been determined in ref. [leuliet, faugeras], by means of a high magnetic field study of quantum cascade structures.

The measured and calculated ratios between the quantum efficiencies are in good agreement.

Work is in progress to perform a similar study on an InP based diode.

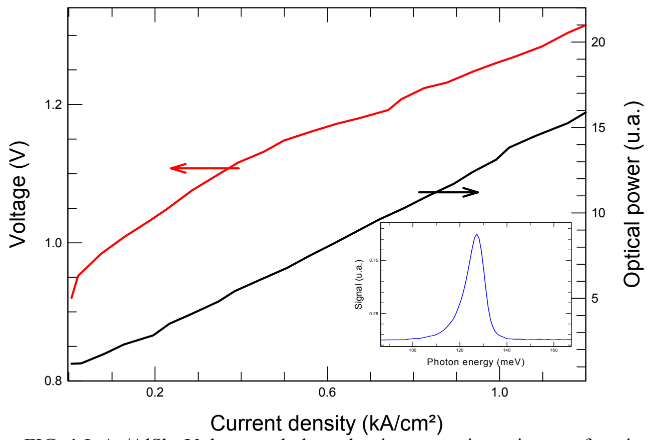

FIG. 1.InAs/AlSb: Voltage and electroluminescence intensity as a function of the injected current density in pulsed operation 500ns at 100 kHz_ in a 160*80 µm2 square mesa at *T*=77 K. Inset: Emission spectrum measured at 78 K at a fixed voltage of V=.1,2V and centred at 127meV.

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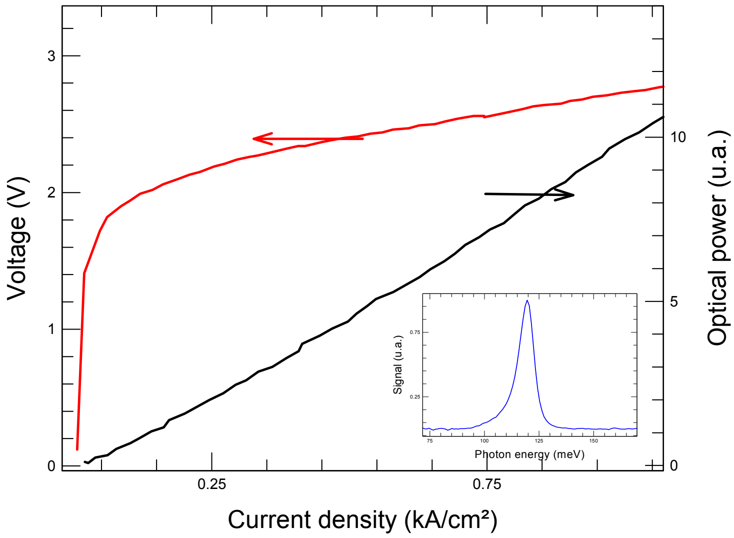

FIG. 2 GaAs/AlGaAs: Voltage and electroluminescence intensity as a function of the injected current density in pulsed operation 500ns at 100 kHz_ in a 200µm diameter mesa at *T*=77 K. Inset: Emission spectrum measured at 78 K at a fixed voltage of V= 2,7V and centred at 120meV.

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