Quantum Cascade Detectors

M. Carras[a], Delga[b], L. Doyennette[b], V. Trinité[a], A. Nedelcu[a], V. Berger[b]
[a]Alcatel Thales 3-5 lab, Campus Polytechnique, 1 Avenue Augustin Fresnel, 91767 Palaiseau, France
[b]Univ Paris Diderot, Sorbonne Paris Cité, Laboratoire Matériaux et Phénomènes Quantiques, CNRS-UMR 7162, 10 rue Alice Domon et Léonie Duquet, 75205 Paris Cedex 13, France

BIOGRAPHY

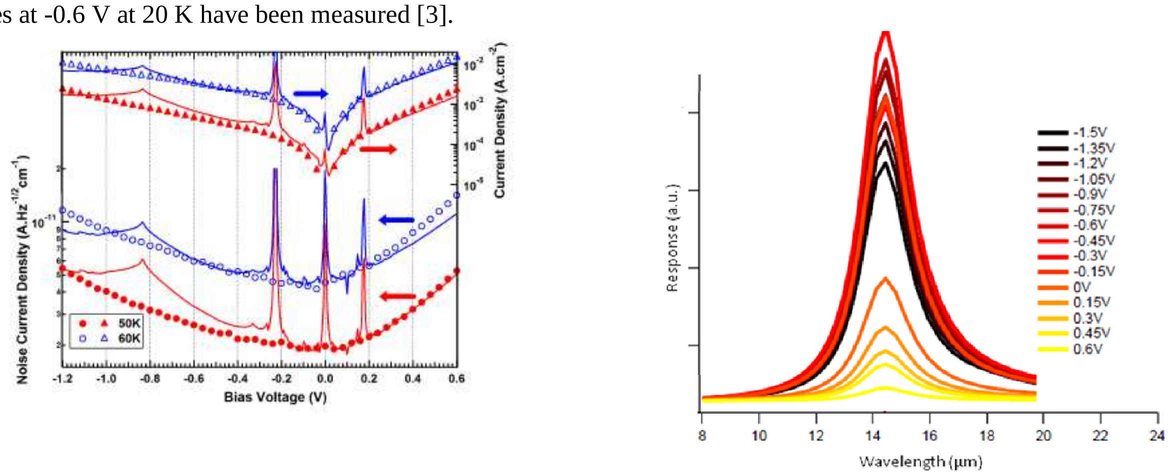
Mathieu Carras: is born in 1979. He graduated from Ecole Centrale Paris in 2003. From 2003 to 2005 he worked on quantum well photodetectors (QWIPs) and InAsSb detector to obtain his PhD of University Denis Diderot.

From 2006 he was Hired in the Quantum Cascade Lasers (QCL) Team and continued to work in collaboration with University Denis Diderot on Quantum Cascade Detectors (QCD) Since 2011 He his head of the QCL team. His research activities are mainly focusing high power QCLs and DFB/ External cavity QCLs for spectroscopy. He also works on the integration of QCL on silicon. He continues to have activities on thermal imaging using quantum wells.

TECHNICAL ABSTRACT

Photodetectors based on semiconductor quantum wells have been developed over the last decades, mostly for thermal imaging applications in the long wave infrared range (LWIR) (8-12 μm). Thanks to the tunability of the quantum well structures, these devices reach nowadays other wavelength ranges: the very long wave infrared range (VLWIR) (12-20 μm) for applications such as space detection and the mid wave infrared range (MWIR) (3-5 μm) for imaging. Quantum cascade detectors have been proposed in 2001 [1] as photovoltaic detectors and studied since 2003 in a collaborative team between III-V Lab and University Denis Diderot in Paris. During those years, QCDs have been designed and fabricated at different wavelength from MIR to TH_z.

We will first present the principle of QCDs. Then we will present the performances of some of those devices. For instance in the LWIR, the detectivity of a QCD at 8 μm operating under no applied bias reaches a value of D*=4.5x10^{11} Jones at 50K [2]. In the VLWIR, AlGaAs/GaAs QCD detectivities up to D*=1.33x10^{11} Jones at 0 V and D*=2.44x10^{11} Jones at -0.6 V at 20 K have been measured [3].



Result of the modeling of 15µm VLWIR QCD: on the left are presented the current and noise modeling and measurement and on the right the response modeling

*Mathieu.carras@3-5lab.fr; phone +33 1 69 41 57 57; 3-5lab.com

We will describe the models we use for the estimation of QCD performances. A particular attention will be given to the modeling of the noise in those devices. We have developed transport model to estimate the transport of electrons. This model shows excellent agreement with experiments. From the current characteristics, it is quite direct to estimate the noise at zero bias. However, it is more complicated to estimate the noise under a moderate bias. We will show how the knowledge of the lifetimes of the electron in the structure is sufficient to estimate the noise characteristics. It is also possible to estimate the response level. Figure 2 show the current modeling, noise modeling and response modeling of a 15µm VLWIR QCD. We will show how this fine understanding enables to increase significantly the detector performances.

In a last part, we will discuss the possible applications of QCD and in particular in comparison to established technologies. For instance we will show that the estimation of QCD performances in a camera opens opportunities especially in VLWIR. We will finally present some future developments.

Keywords: Quantum detectors, Thermal imaging, Quantum wells, Transport and noise modeling.

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