Quantum Well Infrared Photodetectors for two-color MWIR imagery

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Abstract— **Electro-optical characteristics of quantum well infrared detectors designed for multi-color infrared detection in the 3-5 µm spectral range are presented. It is demonstrated that AlGaAs/AlAs/InGaAs/AlAs/AlGaAs structures are well suited for extending the detection range downwards 3 µm. The physics of these structures is investigated and shown to be much more complex than for regular AlGaAs QWIP structures.**

Index Terms— **QWIP, mid-infrared, photodetection, two-color**

The easily tunable and narrow spectral absorption band of GaAs based Quantum Well Infrared Photodetectors (QWIPs) coupled with the mature state of GaAs processing techniques provides a ready basis for fabricating large and complex focal plane arrays for dual-band (MWIR[3-5µm] / LWIR[8-12µm]) or two-color (MWIR/MWIR, LWIR/LWIR) imagery [1-3].

Whereas dual-band and LWIR/LWIR detectors have been successfully demonstrated [4,5], two color QWIP detectors for the MWIR band are still lacking. Two-color detectors in the 3-5 µm spectral range (e.g. 3.8µm / 4.6µm) would allow absolute temperature determination and very long range thermal imaging (thanks to the high atmospheric transmission in the 3.4 – 4.2 µm region). Moreover, they would benefit from the high uniformity, high yield, low 1/f noise intrinsic to III-V QWIPs.

To achieve two-color detection in the 3-5 µm spectral range we studied AlGaAs/AlAs/InGaAs/AlAs/AlGaAs multi-quantum well structures. We report on Figure 1 the spectral responsivities of two detectors covering the spectral range of interest.

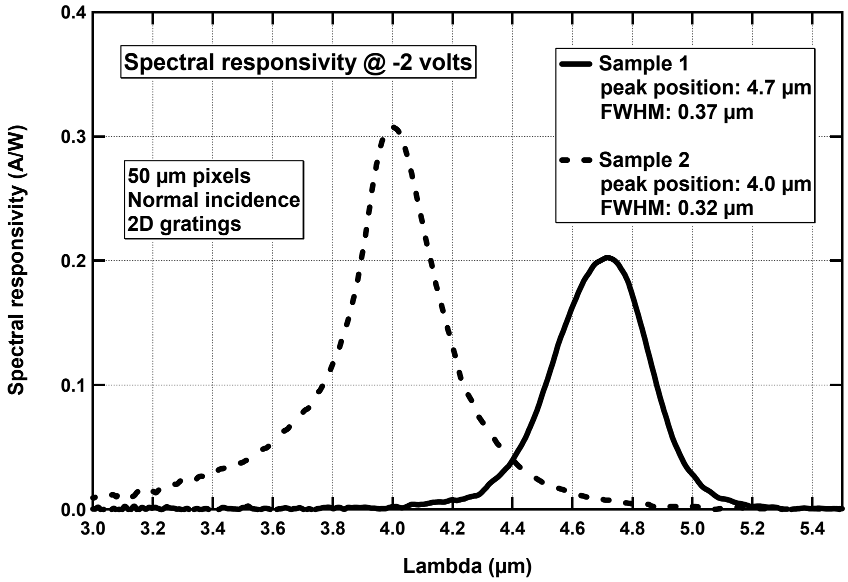

Fig 1. Spectral responsivity of MWIR QWIP detectors

We experimentally investigated the dark current, responsivity and noise characteristics of these structures. We found that impact ionization processes [6] play a very important role, due to the reduced number of quantum wells in the active layer. This forbids simple modeling of the electro-optical characteristics and impacts on the optimal bias voltage.

At low bias voltage the electron capture is deterministic (as in quantum cascade detectors [7]), leading to a capture probability (p_C) equal to one. The influence of the AlAs barriers on p_C is clearly evidenced. At high bias voltage the noise gain exhibits a strong increase, unlike regular AlGaAs/GaAs QWIP structures. In this high bias regime, governed by the impact ionization, the simple emission-capture model proposed by W.A. Beck [8] breaks down. Peak responsivity is also affected.

The performance of the active layer has been measured. Peak detectivities as high as $4 \cdot 10^{11}$ Jones have been obtained on 4.0 µm structures at 90 K and 293 K background (f/2 optical aperture).

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