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QWIP products and building blocks for high performance systems

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Abstract

Standard GaAs/AlGaAs quantum well infrared photodetectors (QWIP) are coming out from the laboratory. In this paper we demonstrate that production and research cannot be dissociated in order to make the new generation of thermal imagers benefit as fast as possible from the building blocks developed by researchers.

Since 2002, the THALES group has been manufacturing sensitive arrays using QWIP technology based on GaAs techniques through THALES Research and Technology Laboratory. This QWIP technology allows the realization of large staring arrays for thermal imagers (TI) working in the IR band III (8–12 μm). A review of the current QWIP products is presented.

In the past researchers claimed many advantages of QWIPs. Uniformity was one of these and was the key parameter for the production initiation. Another advantage widely claimed also for QWIPs was the so-called band-gap engineering, allowing the custom design of quantum structure to fulfill the requirements of specific applications like very long wavelength or multispectral detection. In this paper, we present the performances for Middle Wavelength Infra-Red (MWIR) detections and demonstrate the ability of QWIP's to cover the two spectral ranges (3–5 μm and 8–20 μm).

Last but not least, the versatility of the GaAs processing appeared for QWIPs as an important gift. This assumption was well founded. We give here some results achieved on building blocks for two color QWIP pixels. We also report the expected performances of focal plane arrays that we are currently developing with the CEA-LETI-SLIR.

Keywords: QWIP; Infrared detectors; Focal plane arrays; III–V; MWIR; LWIR

1. Introduction

Seventeen years after the laboratory demonstration of intersubband IR responsivity by Levine [1] in QWIP structures, this type of detector is today

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integrated in operational systems. For the last decade THALES Research and Technology (TRT) has made a great effort in optimizing the performance of elementary detectors, and particularly for operating temperatures around that of liquid nitrogen. Through the development of a self-consistent model that takes into account all the physical and electro-optical parameters of a pixel, we have been able to fabricate QWIPs in the 4–20 μm spectral range whose performance in term of detectivity at a given operating temperature represents the state of the art. Following a first collaboration in 1997 with Sofradir [2] on a demonstrator of a modest format of 144×192, we now together develop and manufacture QWIP FPAs having formats of 384×288 and 640×512. In this article we present the specifications of the 640×512 FPAs built with our QWIP arrays and ISC9803 readout circuits from Indigo. We illustrate the potential of the 384×288 arrays through the specifications of the Catherine-QW imager of Thales Optronique. Decreasing the pitch of FPA is a key point for cost reduction so we present here the features of a LWIR QWIP 640×512 FPA at a pitch of 20 μm that we are currently developing with Sofradir.

In this article, we also give a brief discussion of a program for demonstrating very high performance in two color imagery and thus at a 256×256 FPA level.

2. QWIP products

Combining their respective skills, Thales and Sofradir produce and develop QWIP focal plane arrays for imaging at 9 μm. Thales is in charge of design and fabrication of QWIP arrays, and both hybridization and integration in IDDCA are Sofradir's task. The QWIP processing is perfectly compatible with the Sofradir industrial procedures. Sofradir now produces two devices:

- 384×288 classical QWIP (pitch 25 μm, RM2 or RM5 cryocooler from Cryotechnology).
- 640×512 classical QWIP with a ISC9803 ROIC from Indigo System (pitch 25 μm, 1 W cryocooler).

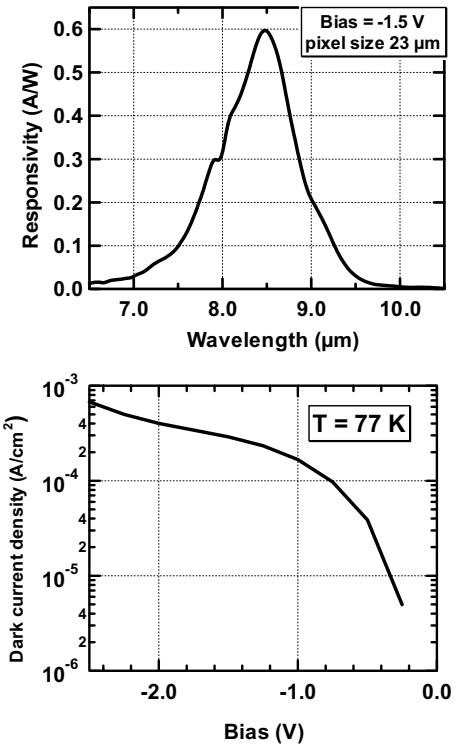

Fig. 1. Typical spectral response and dark current density of a LWIR QWIP IDDCAs.

We report in Fig. 1 the main characteristics of the QWIP active layer used for both formats.

2.1. LWIR384 × 288 FPA

Thales Optronique is now offering thermal imagers based on classical QWIP focal plane in 1/4 TV format. We illustrate the performance of the 1/4 TV QWIP FPA (25 μm pitch) through the features of the Catherine-QW imager [3].

Architecture and performances of this TI are described below.

Specification of Catherine-QW

- Operating spectral bandwidth: 8–12 μm.
- QWIP FPA operating temperature: 75 K.
- Integration time: <5 ms.
- Field of view: $10° \times 7.5°$, $4° \times 3°$, $2° \times 1.5°$ (electronic magnification).
- NETD < 50 mK; NETp < 20 mK (*f*/2.7).