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AlGaAs/GaAs Quantum Well Infrared Photodetectors

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Abstract

In this article, we present an overview of a focal plane array (FPA) with 640×512 pixels based on the AlGaAs quantum well infrared photodetector (QWIP). The physical principles of the QWIP operation and their parameters for the spectral range of 8–10 μm have been discussed. The technology of the manufacturing FPA based on the QWIP structures with the pixels 384×288 and 640×512 has been demonstrated. The parameters of the manufactured 640×512 FPA with a step of 20 μm have been given. At the operating temperature of 72 K, the temperature resolution of QWIP focal plane arrays is less than 35 mK. The number of defective elements in the matrix does not exceed 0.5%. The stability and uniformity of the FPA have been demonstrated.

Keywords: GaAs/AlGaAs quantum well infrared photodetector, focal plane array, multiplexer, dark current, noise equivalent temperature difference

1. Introduction

The solution to a well-known problem of a finite rectangular quantum well (QW) indicates that the energy position of the quantum subbands is determined by several parameters, namely, the width of the quantum well, the height of the barriers, and the carrier effective

640 × 512 FPA assembly module equipped by the germanium lens with D/F = 1:2 aperture is shown in **Figure 19**.

The developed technology for the FPA assembly is reproducible and has a rather high yield percentage of the suitable products well seen from **Figure 20** showing the scatter of the noise equivalent temperature differences and a number of defective elements for the 640 × 512 FPA assembly manufactured on the 5 MBE grown heterostructures.

Figure 20. (A) Scatter of NETD and (B) a number of defective elements in the 640x512 FPAs produced on the five grown QWIP structures.

Figure 21. The photo of the QWIP IDCA.

	ISP SB RAS (Russia) BM20	Sofradir (France) SIRIUS-LW
Array format	640 × 512	640 × 512
Pixel pitch, μm	20	20
Peak sensitivity, μm	8.5–8.6	8.5
FWHM, μm	0.8–1	1
NETD, mK	<35	<35
Operability, %	>99.5	99.9%
Integration time, ms	6	7
Operating temperature, K	72	70–73

Table 1. Comparative characteristics of the GaAs/AlGaAs QWIP IDCA by the ISP of the SB RAS (Novosibirsk) and Sofradir (France).

6.1. Integrated detector cooler assembly

The fabricated and tested 640 × 512 FPA were installed in the body of a vacuum cryostat integrally coupled with a microcryogenic system. Resulted integrated detector cooler assembly (IDCA) is showed in **Figure 21**. A vacuum cryostat performs thermal isolation of the array from the environment to guarantee effective cooling of the photodetector up to the operating temperature ($T = 68\text{--}72\text{ K}$). The radiation from the detected objects is fed to the FPA through an input window made up of the germanium with the antireflection in the range of 8–10 μm and a cooled diaphragm with a relative aperture $F/2$ designed to reduce the background illumination. A low pressure in the vacuum cryostat is provided by a getter, whose reactivation is carried out by passing an electric current through it. Typical operating temperatures for the FPA based on the QWIP with the wavelength range 8–10 μm are 68–72 K. Thus, the powerful microcryogenic systems ensuring a cooling capacity at an operating temperature of 70 K not less than 0.4 W and the power consumption not more than 20 W are needed to provide the required temperature in a full range of climatic conditions.

As one can see from **Table 1**, the parameters of the developed 640 × 512 QWIP IDCA are comparable with those of the Sofradir products.

7. Conclusions

The technology of manufacturing the AlGaAs/GaAs QWIP FPA has been discussed. The parameters of a FPA of 640 × 512 format with a 20-μm pitch for a spectral range of 8–10 μm have been described. At an operating temperature of 72 K, the temperature resolution of the QWIP FPA is less than 35 mK. The frame rate is 100 Hz. A number of defect elements in the array do not exceed 0.5%. It is shown that the parameters of the QWIP FPA fabricated by Rzhzanov Institute of Semiconductor Physics of SB RAS meet the world class standards.

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