BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Journal of Electronic & Information Systems
https://ojs.bilpublishing.com/index.php/jeis

ARTICLE

TEC Colling Shortwave Infrared 320×256 Focal Plane Detector

Jun Jiang*

Kunming Institute of Physics, Kunming, Yunnan, 650223, China

ARTICLE INFO

Article history
Received: 11 September 2020
Accepted: 18 September 2020
Published Online: 31 October 2020

Keywords:
Short wave
Mercury cadmium telluride
Shortwave focal plane detector
Thermo electric cooler
Infrared

ABSTRACT

The short-wave HgCdTe thin film material was grown by liquid phase epitaxy on CdTe substrate, Adopt n on p injection bonding and function and flip-flop mixing process, With a low noise readout circuit, sealed with a high airtightness cellular-metal shell, Using a four-stage Thermo Electric Cooler (TEC),320×256 Short Wave Infrared Focal Plane Cooling Detecto r available to operate at near room temperature (210K). Its main photoelectric performance are signal-to-noise ratio greater than 400, non-uniformity equivalent to 4.69%,operability equivalent to 99.76%,frame rate equivalent to 115Hz,component weight less than 150grams.

1. Introduction

Shortwave infrared imaging can adapt to the need of night vision and obtain clear imaging. Shortwave infrared imager can be used as a new generation of night vision equipment. It can be widely used in the sea, land and air, such as tank, vehicle, aircraft, ship and other night driving observation equipment, battlefield front surveillance equipment, single soldier helmet, gun-eye night vision detection equipment [1-3]. In addition, it can also be used as a light weapon day and night sight, motor platform night auxiliary driver, etc. Short-wave infrared imaging makes up for the deficiency of mid- and long-wave infrared night vision, fills the blank of short-wave infrared atmospheric window, and has unique advantages in many fields [4].

Since short-wave infrared detectors can work at near room temperature (≥200 K), low-cost and simple-structured thermo electric cooler can be used instead of expensive and complex Stirling coolers or throttling coolers, which have great advantages in the cost, weight and reliability of detector components and have wide application prospects [5].

2. Design and Implementation of Short-wave Mercury Cadmium Telluride 320×256 Focal Planar Detector

2.1 Structural Design of 320×256 Focal Plane Detector Assemblies for Mercury Cadmium Telluride in Short Waves

Shortwave 320×256 cadmium telluride mercury focal plane detector assembly using planar p-n junction

**Corresponding Author:*
Jun Jiang,
Kunming Institute of Physics, Kunming, Yunnan, 650223, China;
Email: jj.wjy @163.com

 DOI: https://doi.org/10.30564/jeisr.v2i2.2383

structure, Based on zinc cadmium telluride (CdZnTe) substrate, Using liquid phase epitaxy (LPE) technology to grow shortwave HgCdTe (HgCdTe) films, Through surface treatment, surface passivation, ion implantation, To form focal plane arrays, Connected to the CMOS process readout circuit by planar flip-flop interconnection, Form a hybrid focal plane detector chip, Detector assemblies are cooled by a four-stage thermo electric cooler (TEC), sealed with a high airtightness cellular-metal shell.

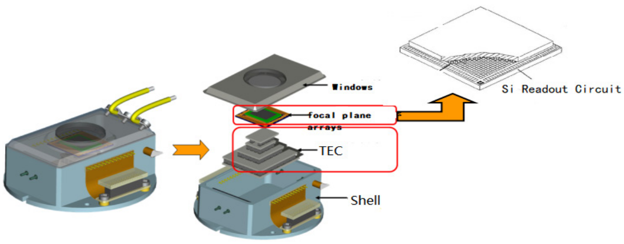

Figure 1. Composition of the detector assembly

How the shortwave 320×256 infrared detector module works: the infrared radiation of the target object converges to the photovoltaic diode array through the optical system. the focal plane array topology diagram is shown in figure 2. the photovoltaic diode converts the absorbed photons into photoelectric signals. the integrated capacitance of the corresponding pixel of the readout circuit is charged in the integral time and converted to voltage signal output after transfer and amplification. Through optical scanning, the signal processing circuit of the system encodes, modifies and displays the infrared information per element, and then forms the infrared thermal image of the target band.

2.2 Process Realization of Short-wave HgCdTe Thin Film Material and Focal Plane Detector Chip

In the study of short-wave HgCdTe film growth, the process route of raw material purification and high stability liquid phase epitaxial growth was designed, the high quality liquid phase epitaxial growth of HgCdTe film and the annealing technology of substrate material were studied.

The detector chip process was designed. a short wave 320×256 infrared detector chip with high uniformity was prepared by material surface treatment, bonding technology, surface passivation and penetration enhancement technology, ohmic contact of short wave materials, reactive etching research, molding process research, interconnection technology and other key technologies, as shown in figure 3.

Figure 2 Image element array topology diagram

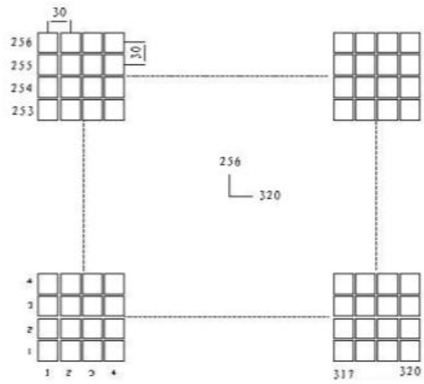

Figure 2. 320×256 focal plane array topology

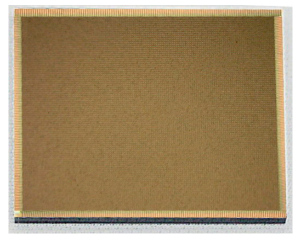

Figure 3. Physical photograph of HgCdTe shortwave 320×256 focal plane chip

2.3 Design of Readout Circuit

The matching degree between the input level of the readout circuit and the characteristics of the detector unit determines the signal injection efficiency after the interconnection between the two, which affects the performance of the focal plane detector. The short-wave CdTe detector has high impedance and small photocurrent, and the optimal design of the input stage of the readout circuit will be the key to the development of the readout circuit. Design of readout circuit is based on submicron silicon CMOS technology. The readout circuit enables FPA to integrate (CTIA), store, line strobe, and sample-hold signals from photovoltaic diodes, using integration while read (IWR) mode. The design of the readout circuit adapts to the requirements of snapshot operation, and the integral time is programmable. The overall structure of the detector readout circuit is shown in figure 4.

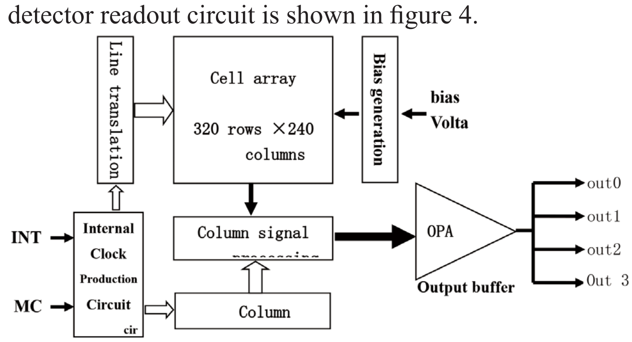

Figure 4. General structure of readout circuit

DOI: https://doi.org/10.30564/jeisr.v2i2.2383

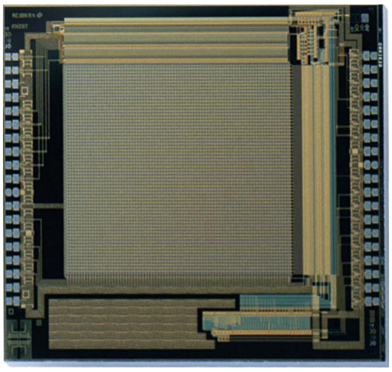

Figure 5. Physical photograph of 320×256 readout circuits of HgCdTe in short wave

2.4 Coolers

In this study, a four-stage thermo electric cooler was used as a refrigeration source for the short-wave focal plane detector to make the detector work around 200 K.Design and Development of Special Type Four-Stage Thermo Electric Cooler[6].In order to meet the demand of high current operation of the cooler, the technical size, logarithm and layout structure of the grain column are designed. The thermo electric cooler adopts four-stage structure, and the column material adopts Sb Bi-Te alloy semiconductor crystal. Each layer is connected by ceramic sheet. The first stage is 128 columns, the second is 52 columns, the third is 22 columns, and the fourth is 10 columns. Because of the small size (length and width size less than, height size less than), light weight, high reliability and so on. The volume and weight of the whole focal plane detector assembly can be effectively reduced. It provides great convenience for the design of the whole machine. Because of the high reliability of sthermo electric cooler, the reliability and service life of the whole detector assembly can be greatly improved, and the cost and price of the detector assembly can be greatly reduced because of the use of low cost thermo electric cooler instead of the expensive Stirling refrigerator.

2.5 High Airtightness Ceramic-metal Shell Structure Package

The principle of generality, small volume, light weight and high reliability are fully considered in the package structure. the shell components are all metal structure, integrated with thermo electric cooler, and side lead structure. the shell pin design must meet the requirements of detector chip signal drive and readout, and have good electromagnetic shielding ability.Packaging all parts using strictly controlled surface treatment process to ensure vacuum life and reliability.

The low temperature solder is selected according to the characteristics of the highest energy temperature of the TEC refrigerator, and the process of rapid cooling from the welding temperature is realized by using the accurate temperature control welding equipment to ensure that the TEC is not damaged. And meet the technical requirements of welding parallelism and position.

The metal-encapsulated window uses sapphires to ensure transmission 1μm -2.5μm infrared bands [7]. The suction agent is arranged in the package, which ensures that the device can activate the vacuum by charging the suction agent in the later stage, thus prolonging the service life of the detector.

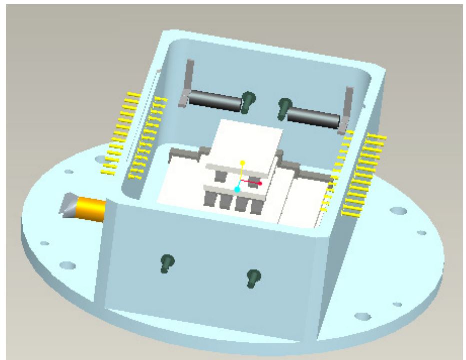

Figure 6. Internal structure of detector package

3. Component Performance and Environmental Testing

The photoelectric performance of the TEC cooling shortwave infrared 320×256 focal plane detector is tested. The main technical specifications are as follows: working temperature 210 K, signal-to-noise ratio >400, non-uniformity 4.69, operability 99.76%, frame frequency 115 Hz, component weight less than 150 grams.

The environmental adaptability of this component is studied. The contents of environmental test include high temperature storage, low temperature storage, high temperature impact, low temperature impact, high temperature work, low temperature work, mechanical impact and impact. After the environmental test, the component performance did not change obviously.At the same time, the performance of components stored in conventional environment for one year is re-tested, and the performance is not declining.

4. Conclusion

A shortwave infrared 320×256 focal plane detector with low price and simple structure is used to replace the expensive Stirling refrigerator or throttling refrigerator with

DOI: https://doi.org/10.30564/jeisr.v2i2.2383

complex structure.

References

[1] Yi Cai, Xu Hu. On Short Wave Infrared Imaging Technology and Its Military Applications Infrared and Laser Engineering[J], 2006, 35(6): 643-647.

[2] Jinxiang Fan. New advances in infrared imaging technology and systems. Proceedings of the 2015 IR and remote Sensing Society Conference, 2015, 304-309.

[3] Shuangqing Wu, Guang Yang, Baohua Long. Short-wave infrared imaging technology and its space application. The 19th Annual Conference of Shanghai Infrared and remote Sensing Society. 2015: 71-76.

[4] Shuang Liang, Zhiyong An, et al. Characteristics of scene radiation acquisition by short-wave infrared imaging spectrometer[J]. Journal of Optics, 2010(5): 1304-1307.

[5] Qisen Cheng. Research on Key Technologies of Information Acquisition for Light Small Non-Cooled Short-wave Infrared Camera[D]. 10 University of Chinese Academy of Sciences, 2018.

[6] Tao Wang, Feng Cao, et al. A Temperature Control Technology [J]. Based on Non-Cooled Infrared Detector Electronic Technology and Software Engineering, 2019(12): 112-114.

[7] Qing Guan, Linwei Liao, et al. of sapphire substrate visible light/laser/ mid-infrared multispectral window film Optics and Optoelectronics[J]. 2017(06): 66-72.

[8] Junhua Liu, Xinjiang Gao, Xun Zhou. Technical Progress of Short-wave infrared InGaAs focal plane detectors Semiconductor optoelectronics. 2015(05).

DOI: https://doi.org/10.30564/jeisr.v2i2.2383