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MODERN BOLOMETRIC INFRARED DETECTORS IN THERMAL IMAGING SIGHTS

Prof. A. Chwaleba, Ph.D.D. Rodzik, Ph.D.J. Szczurko

Military University of Technology
Poland, Warsaw
drodzik@wat.edu.pl, jszczurko@wat.edu.pl

This analytical and panoramic paper considers the construction and properties of the matrices based on bolometric semiconductor and graphene. The impact of dimensions and thermal parameters of the matrix on the quality of the thermal image of the object and the ability to distinguish it from the surroundings is described.

Key words: matrix, infrared detector, bolometer, graphene, thermal imaging sight.

Introduction. Thermographic sight is a thermal imaging device that provides aiming at any time of day or night, using the temperature difference between the object and its surroundings. It allows recognizing the object, regardless of the lighting and adverse weather conditions (mist and smoke levels). It is a type of thermal imaging camera (Imager) precedes the collimator sight that adds to the image spot lights. This camera records emission of the infrared radiation (long-wave radiation). Thermal imaging sight is composed of the following blocks: lens, infrared radiation detector matrix, electronic signal processing circuit, control system, power supply and monitor (see Fig. 1). The matrix of infrared radiation detector is the most important from the point of view of the object detection.

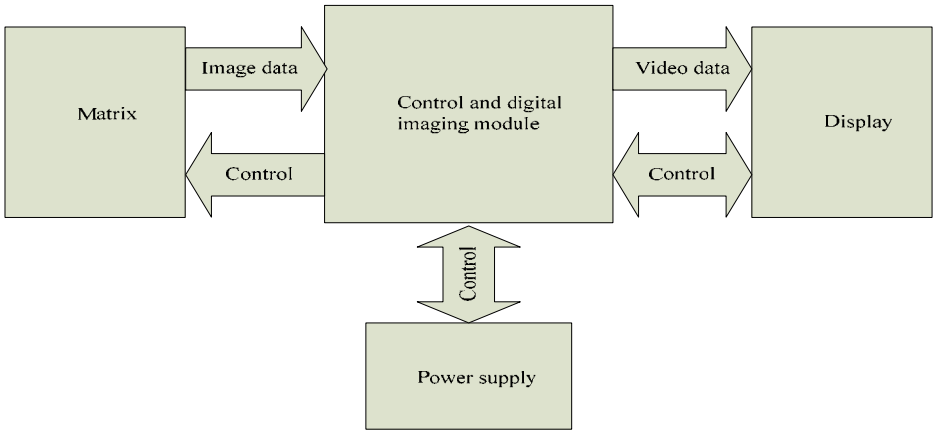

Fig. 1. Module diagram of the electronic thermal imaging sight.

Matrix bolometric infrared detectors. The transducer (detector) of infrared radiation is one of the most important blocks in the structure of the infrared camera, as it converts infrared radiation into an electrical signal. This process should be effective in the infrared bands, where it is well transmitted through the atmosphere. Due to the strong attenuation in the atmosphere of infrared radiation in the 3—5 microns band, thermal imaging cameras (and thus infrared detectors) work as short-wave devices in the 3—5 microns band, or as long-wave devices in the 8—14 microns band. The sights infrared cameras are mostly long-wave radiation detectors.

Detectors can be cooled or noncooled. Modern infrared detectors are matrices, containing several millions of sensors (measuring points, pixels). Therefore, they are characterized by using the dimensional

resolution, which is equal to the number of sensors (pixels) in the horizontal and vertical directions (e.g., 640×480). This is an important parameter of infrared cameras.

Another important parameter of infrared cameras, which determines the infrared detector, is the thermal resolving power (e.g. 40 mK). The thermal resolving power is an ability to distinguish the temperature selected points of thermogram.

By physical basis of their operation, infrared detectors can be divided into two groups — thermal and photon detectors. Thermal infrared detectors, also called bolometric detectors, are used in thermal sights for the reasons of maintenance and price.

Thermal infrared detectors may be sensitive to electromagnetic radiation in a wide spectral range (from x-ray to the radio emission). Spectral width of the thermal infrared detector is limited by sensor design. Spectral width of thermal infrared detector can be narrowed by an appropriate choice of material and size of windows and enclosures (e.g. 7—14 microns).

Generally, thermal detectors are non-selective, not very fast, and usually noncooled. Thermal detectors are bolometricand pyroelectric matrices or matrices with stacks of thermocouples. The infrared sights primarily used bolometric matrices. Bolometers are thermoresistors made of a material having a high thermal coefficient of resistivity (2—5%/K).

We have studied the construction of graphene bolometers, which do not require cooling. Graphene is a monoatomic layer of carbon atoms arranged in a honeycomb structure and has a number of interesting properties. Among other things, grapheme absorbs light in a wide band spectrum — from ultraviolet to infrared. Graphene in its normal form (as a single layer) does not exhibit thermal sensitivity, since the electrons in graphene are weakly coupled with phonons (quantum oscillations of the crystal lattice), because the temperature of atoms does not change significantly as a result of the absorption of light. Graphene resistivity does not depend on the temperature.

After placing two layers of graphene, electric field was applied perpendicular to the bilayer structure, which gives rise to the graphene bandgap energy. The structure of the metal becomes a semiconductor and its resistance becomes highly dependent on the temperature. Currently graphene bolometers are implemented in the operating temperature of about 6 K, and the work on the construction of grapheme bolometers that would operate at room temperature are being carried out.

Summary. Important parameters of thermal imaging sights, due to the efficiency of objects identification, are dimensional resolution of infrared detectors and thermal resolution capability. The first parameter determines the quality of thermal images, while the other determines the ability to distinguish the object from the surroundings. For these reasons, noncooled graphene bolometric detectors are the prospective ones. Their resolving thermal power may be less than 10 mK.

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А. Хвалеба, Д. Роджик, Я. Щурко

Современные болометрические инфракрасные детекторы для тепловизионных прицелов.

В работе рассмотрены структура и свойства болометрических полупроводниковых и графеновых матриц. Описано влияние их тепловых и размерных параметров на качество термограмм цели и способность отличить ее от окружающей среды.

Ключевые слова: *матрица, инфракрасный детектор, болометр, графен, тепловизионный прицел.*

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