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A NEW INFRARED RADIATION DETECTION SYSTEM AS AN INSPIRATION FOR THE POTENTIAL CONSTRUCTION OF A RADIOMETRIC DETECTOR

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Abstract: *In the search for new detection systems that are of great importance in various fields, physical phenomena play a major role. The radiometric detector relies on a powerful combination of the thermophoretic effect and the holographic observation method. When we use holography to record the deformation of the nanometer structure caused by the effect of infrared radiation, we only have to measure the mechanical deformation and convert it into an output signal. The perfection of modern solutions lies in the simplicity of the applied technology.*

Keywords: *Detectors, Infrared radiation, Holography.*

1. INTRODUCTION

In modern times, infrared detectors are widely used in various fields. [1] Thermal cameras form an image using infrared radiation, and this kind of imaging has a particular application for military purposes. The main advantage of thermography is the possibility of night observation without the need for additional lighting. This property is a consequence of the property of all objects with a temperature above absolute zero to emit infrared radiation. These features are of great importance for military purposes, since thermal imaging devices are especially effective at night and in low visibility conditions.

There are two significant groups of infrared detectors, thermal and quantum. Each group has its advantages and disadvantages in terms of effect, working conditions, production price, etc. However, there is a constant need to find new mechanisms, which will overcome the current limitations in the detection of thermal radiation. A new way to detect thermal radiation described in this paper is based on the radiometric effect. [2] The radiometric effect is a thermo-mechanical phenomenon caused by temperature gradient formed on the piece of material after this material absorbed some electromagnetic radiation. Parallel to the existence of a temperature gradient, the material has such a structure that its characteristic dimension is of the order of the mean free path of the surrounding gas molecules.

The radiometric effect essentially refers to the action of a force that leads to material deformation. This force is called the radiometric force and is formed when the molecules of the surrounding gas carry much more mechanical impulse from one side of the material, from warmer side.

The energy of the invisible parts of the electromagnetic radiation spectrum is converted in motions of submillimeter size particles. The conversion of the energy of invisible electromagnetic radiation into mechanical displacement is detected by the holographic method. [2, 3]

2. EXPERIMENTAL

Different butterflies' wings were examined to propose a new infrared sensory system. The change of the color spectrum on the natural structure of the butterfly's wings was used, caused by thermal influence, and thermophoretic effect as a consequence of the process. [4]

Different physico-chemical parameters that could have an influence on the thermophoretic effect on the wing were investigated. The analysis of the obtained results definitely showed that the main parameter of influence

lies in the corrugation of the physical structure. Further analyzes defined the ideal structure for infrared radiation detection - a “herringbone” structure.

The preferred directions of exploitation of scientific knowledge from previously described research can be presented in the following examples of concrete engineering application:

1. Monitoring and surveillance of the area (battlefield in military application);

2. Detection of dangerous substances and unexploded mines;

3. Significant reduction in the number of false alarms due to multispectral observation;

4. Improved detection, recognition and identification of objects;

5. Border control, human smuggling and illegal human trafficking;

6. Suppression of the expansion of infectious diseases by precise control of people's temperature.

Finally, it is proposed to make a sample that structurally corresponds to one of the examined samples from artificial materials with similar characteristics (polymers). It is planned to test the artificial samples made in the same way and improve them in the direction of manufacturing and commercialization, that is, in terms of practical application.

3. RESULTS AND DISCUSSION

By carefully measuring the sensitive selected structures, i.e. their parts, a drawing of the elements of the “herringbone” type structure was sketched. The drawing shows the measured dimensions in micrometers and is shown in Figure 1. This drawing represents the basis for further prototyping of the sensor element of the detector.

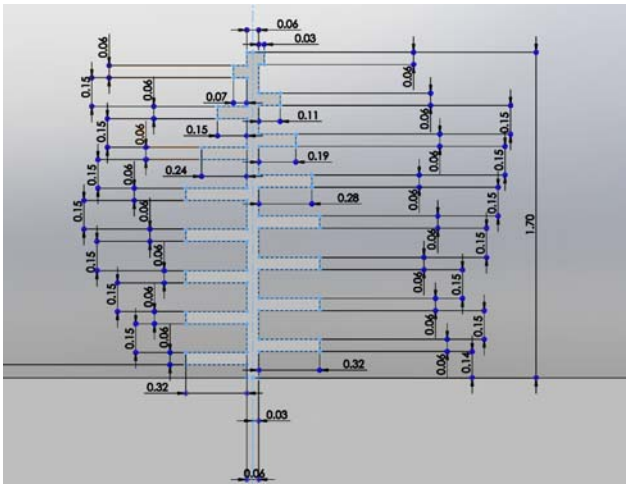

Figure 1. Constructive drawing of dimensioned herringbone (all measurements are given in micrometers)

Sensor elements made according to the previous drawing are put together into one integrated sensor that contains a certain number of individual structures of the "herringbone" type. This number can only be defined in the prototype testing phase. It is necessary to examine the possibilities of stacking into a one-dimensional, two-dimensional and three-dimensional structure in terms of rows and layers. The sensor integrated in this way is applied to the detector chip. The chip would be tested in two variants: with and without protective glass. After testing, the optimal solution would be determined.

The dimensions of the chip are definitive at the moment when the final technological documentation for the production of the sensor element itself as well as the chip is determined. Technological documentation also provides instructions for applying characteristic structures of the "herringbone" type on the base of the detector chip. This operation depends on the selected polymer and the final dimensions of the chip.

In the final assembly, apart from the detector chip, there would be a case with an optimized holographic system, a small computer for data processing and a monitor for displaying the output information.

As a final proposal of the constructive documentation, the scheme of the detector is given in figure 2.

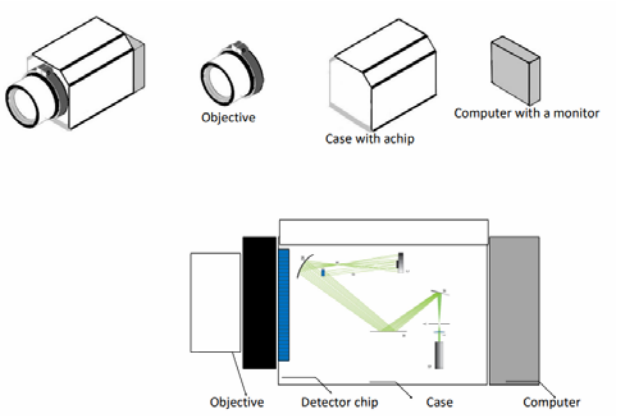

Figure 2. Scheme of the proposed detector

A modified holographic system - an interferometer - is installed in the housing, right behind the detector chip. The exact system configuration is concluded after examining several possibilities. The interferometer is, in addition to the sensitive corrugated structures, the most important part of the innovation of the detection system. The possibilities of the holographic method are very significant and are described elsewhere.

Three-dimensional printing technology [5] is foreseen for the production of the sensory element, artificial structure of the "herringbone" type. A kind of polymer appears as a logical solution for standardizing materials, bearing in mind the natural structure of a butterfly's wing. [6] Polymer in the variant of the starting material does not have a specific form, but appears in the form of powder, solution, granulate, etc. First, a "preliminary" shaping process is performed, from which a certain semi-finished product is created, which is further shaped by classical shaping procedures.

Stainless materials are chosen for all other parts of the detector (except glass). These parts are subjected to

classic metal processing step by step according to the technologies developed for each part separately.

4. CONCLUSION

In accordance with modern military technologies, and from the aspect of optics, the need to find new infrared detection mechanisms was recognized. In this sense, the thermophoretic effect was identified as interesting and of potential importance and the study of it was done using the holographic method. The price reduction and simpler maintenance technologies represent the main advantage of this type of system. The goal for further improvement is to define the final solution with the smallest possible dimensions and to test the efficiency of the final product.

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