Experimental Assessment of the Angle Emissivity for Materials in Microelectronics

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Abstract – **Materials with a wide range of smoothness and kind are used in microelectronics. The self emission of the bodies is used for temperature measurement by distance methods. A knowledge of their emissivity including at different angles of observation is necessary for that purpose.**

The paper presents the results from the experimental assessment of the emissivity for different materials used in microelectronics and electronics.

Keywords **– thermography, emissivity**

I. INTRODUCTION

The thermographic methods for surface temperature measurements of the bodies are known for centuries [1]. They can be applied at investigations of different objects in engineering, including electronics [2]. The characteristics of the elements in electronics and microelectronics in particular are that they have small dimensions (topology forms) and different materials. The observation of such objects can be made by cameras with high resolution. Such camera is the FLIR P640 camera, supplied with extra lens which enables registration of element with size 50 μm. During micro-objects' investigation in different cases we have different angles of observation, which requires taking into account the emissivity for different angles. When certain type of material is used we can assess the emissivity by experimental measurements [3]. The aim of the present article is the introduction of the angle dependence of the emissivity for different materials, used in microelectronics.

II. EXPERIMENTAL SETUP

Emissivity depends on factors such as temperature, emission angle, and wavelength. A typical engineering assumption is to assume that a surface's spectral emissivity and absorptivity do not depend on wavelength, so that the emissivity is a constant.

For carrying out the experiments (фиг.1) there is used a pipe 1 made of a heat insulating material with emissivity 0,96. In the pipe there is placed a rotating pad 2 (a sample holder). A scale for reading the angle movement 4 is placed over the pipe, and the angle of pad rotation is read from the pointer 3. The pointer is immovably connected with the pad.

The camera can be moved and the distance to the rotating pad can be changed.

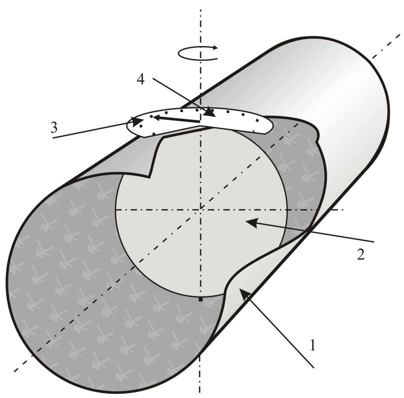

Fig. 1. Experimental setup.

III. EXPERIMENTAL RESULTS

The experiments are implemented with different patterns representing materials used in electronics and microelectronics. Solid patterns are used such as polycrystalline materials (CT50-1, Al_2O_3 and others), composing materials as FR4, as well as pads with topologic elements. On fig.2 there is represented an outlet thermograph image of a hybrid integrated circuit containing layers from gold, nickel-chrome, photoresist.

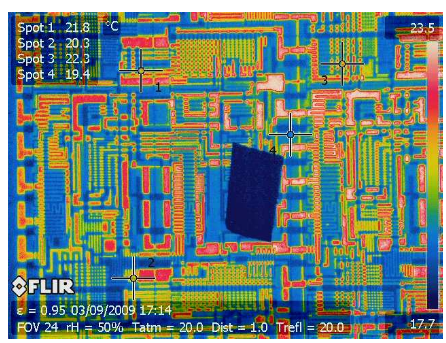

Fig. 2. Thermograph image of a hybrid integrated circuit.

For the complex investigation a few check-points are used, which are placed in different regions and on different materials respectively. On fig.3 there is shown an image of

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the working environment of the camera in the process of the adjustment of the emissivity of a database for a temperature-control.

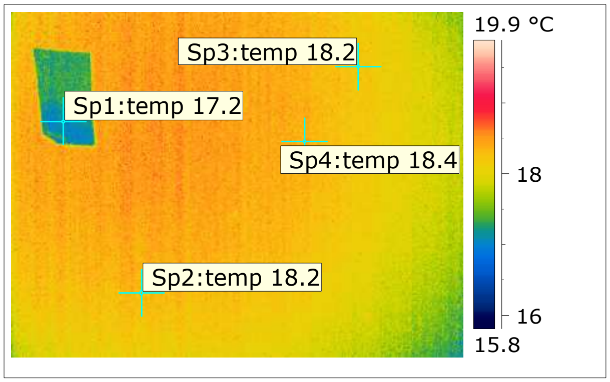

Fig. 3. A working thermograph image.

The visible temperature and its change according to the observation angle is measured for the different patterns – fig.4.

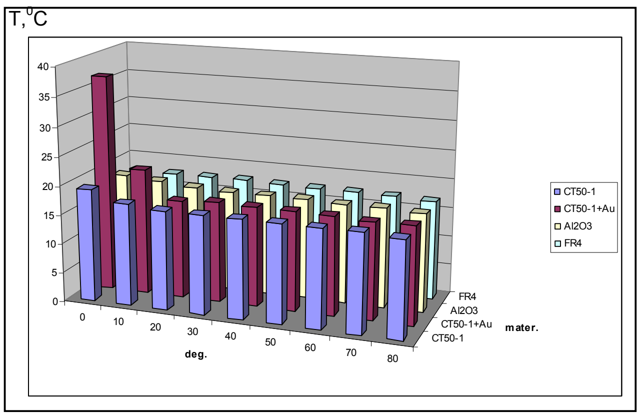

Fig. 4. Visible temperature distribution for different materials according to the observation angle.

As far as the observed temperature is a linear function of the emissivity, the alteration of the visible temperature by the observation angle should be demonstrative for the emissivity change. Such results for the relative temperature changes are shown on fig.5.

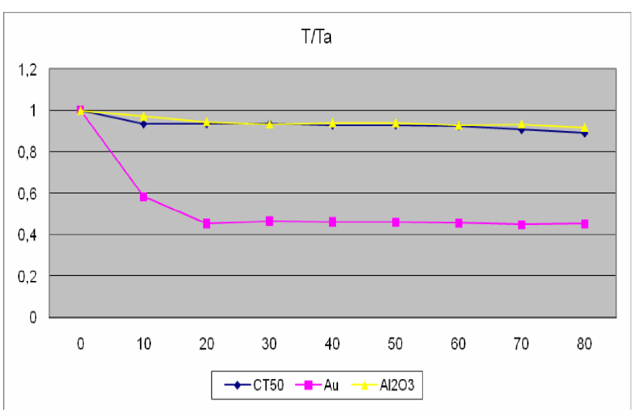

Fig. 5. Relative temperature change T/Ta according to the observation angle.

In fact at small angles (perpendicular observation) from a small distance we have a significant effect on the absolute value of the emissivity. It is obvious that for gold we have a significant temperature change. That is as a result of the influence of the reflected temperature of the ambient, the camera in particular

For escaping from this effect a precise adjustment of the working regime of the camera must be made by taking into account of the distance and the reflected temperature. The emissivity for gold it is obtained to be 0,026. Having in mind the upper factors a graph is made for the alternative emissivity change – fig.6.

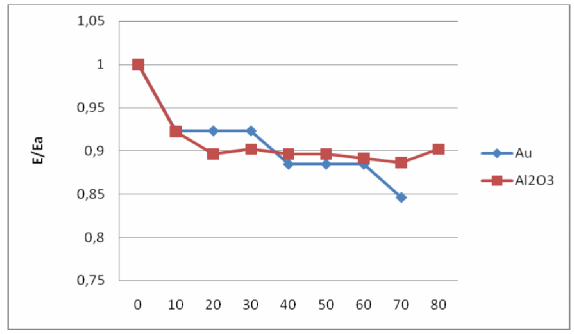

Fig. 6. Alternative emissivity change according to the observation angle.

Because of the small values of the emissivity for some of the patterns and the limitations in the camera resolution it is not possible a smooth graph to be obtained with a high resolution of the values.

IV. Conclusion

It is investigated the thermal emissivity change for different materials in electronics and microelectronics according to the observation angle. For the majority of materials in the range of 60-70 degrees the change is minimum and can be compensated during the data analysis. At the small observation changes to 15 degrees and a small reflection coefficient (under 0,04) it is necessary to read the reflected temperature with a high accuracy - of the order of 0,03 degrees.

Acknowledgement

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