У49 **Thermomechanical sensitivity of bimaterial IR-sensors based on microoptomechanical systems**

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Uncooled bimaterial thermal sensors with optical readout that compose microoptomechanical system (MOMS) are perspective radiation detectors in infrared range. Operation of the devices is based on thermomechanical effect causing bending of a bimaterial microconsole with temperature change. The bending occurs due to a difference between thermal expansion coefficients of a pair of materials used for console fabrication. The bending value makes several nanometers per 1 K of temperature change.

The heat absorbing element of the IR-sensor is a membrane of submicron thickness which is thermally insulated from the substrate. The membrane is attached to the bimaterial microconsoles. Thermal insulation is provided by a vacuum gap between the membrane and the substrate, by microconsole construction, and by choice of microconsole materials. The developed construction of the bimaterial sensor has a high thermal resistance preventing sink of the thermal radiation absorbed by the membrane into the substrate.

This work contains measurement results of thermomechanical sensitivity of the uncooled bimaterial MOMS sensors with optical readout. The purpose of the work was to determine the effectiveness of topological solutions suggested for the sensors.

The heat-sensitive membrane of the sensor was made of silicon nitride by etching-out a sacrificial silicon oxide layer located under it. Membrane thickness is equal to about 400 nm. To improve conditions for etchant access to the sacrificial layer, the membrane has openings uniformly distributed over its surface. The membrane is suspended over the substrate surface at a distance of 500 nm approx. by using narrow microconsoles (width is equal to 8 µm). The bimaterial regions of the consoles were formed of aluminium deposited on a substrate of silicon nitride.

To minimize thermomechanical deformations of the membrane during manufacturing process, a stiffening grid is used. The stiffening grid technology consists in forming grooves on the surface of the sacrificial layer. After deposition of a layer constituting membrane body, stiffening ribs of the membrane are formed. There were suggested several designs of bimaterial sensors having double-armed consoles. The double-armed consoles allow to compensate thermal deformations in the bimaterial structures caused by high-temperature processing steps.

In order to measure the thermomechanical deformations of the IR-sensors, the scanning electron microscope (SEM) JSM-6490LV (Jeol) and the optical profiler Wyko NT9300 (Bruker) were used. Sample temperature was set with the special vacuum compatible stage MK3 (Deben)

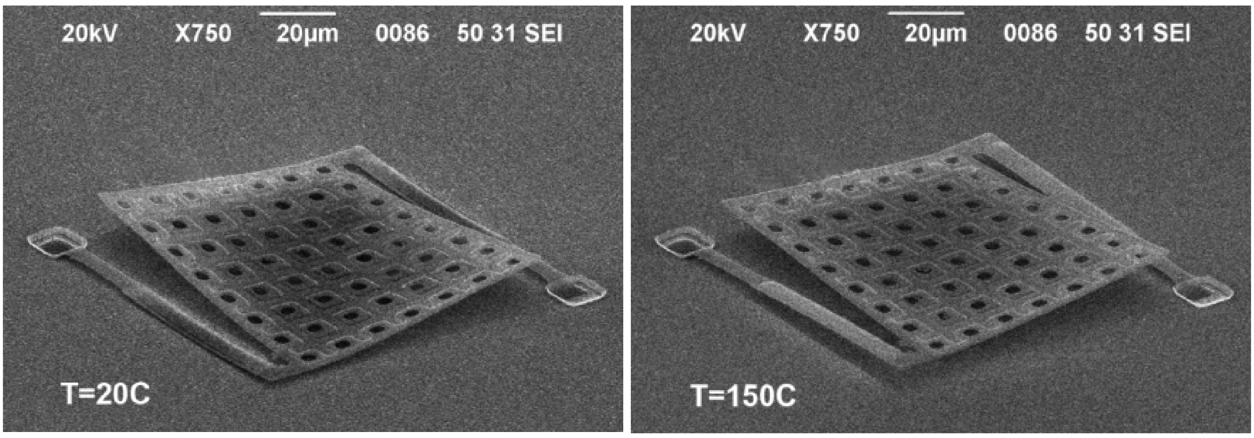

Fig. 1. Bimaterial thermal MOMS sensor at two different temperatures. The images were obtained with SEM.

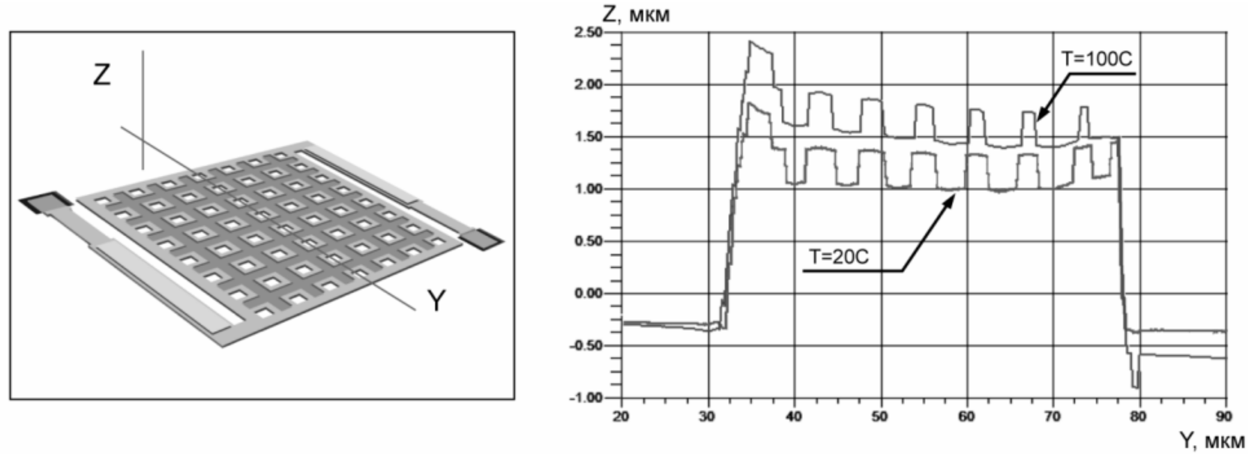

Fig. 2. Membrane positions of the bimaterial MOMS sensor at two different temperatures. Profile measurement of the membrane is carried out with optical profiler.

having built-in Peltier element. The mentioned stage provides assigning, control, and measurement of temperature within -25…+150°C range.

The essential advantage of the employed investigation methods is the possibility of visual control of operation of the bimaterial MOMS sensors. Post-processing of the measurement results by applying animation procedures to frame series permits revealing of dynamics of mechanical response of the elements on the thermal exposure. Micrographs of a MOMS sensor at two different temperatures (T=20ºC and T=150ºC) are presented in Fig. 1. It is seen well in the figure that at room temperature there is a diagonal deformation of the membrane which becomes weaker after heating. The sensor heating causes the membrane lifting which can be quantitatively estimated by measuring membrane profile at different temperatures. By determining a displacement δz of the sensor while temperature changing δT, the thermomechanical sensitivity $K_{ZT}=\delta z/\delta T$ can be found. The measurement results are presented in Figs. 2 and 3.

In the presented work, comparative measurements of different designs of bimaterial MOMS sensors are performed. The obtained results allow to determine the most promising design solutions for building uncooled infrared focal plane arrays with optical readout.

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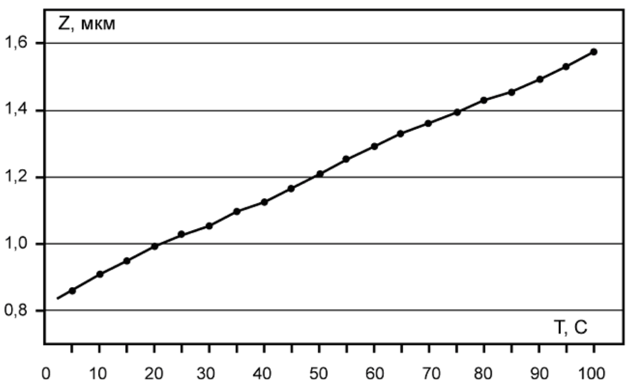

Fig. 3. Displacement of the membrane of the MOMS sensor versus temperature. Thermomechanical sensitivity $K_{ZT}\approx$7.5 nm/°C.