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Microrelations for Diagnostic Devices

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Introduction

When it is possible to compare characteristic sizes of the system with the scale of coherence of the electric wave function, the phenomenon of the quantum size effect and the features of the system become dependent on its form and sizes. The ability of the modern semiconductor technology to create materials and structures where the quantum size effect materializes gives a possibility to explore the functionality of such small-sized systems and opens wide perspectives to use them for electronics and optoelectronics. That is why the ideology of the electronic technology changes because the features of separate quantum states, not of the flows of a big amount of electrons become the most important. This special trend in the physical material, technology and electronic technology is attributed to nanotechnology today.

The linear sizes of functional elements of the modern microelectronics are made of the units of microns. The exploration and practical use of the structures which sizes are less than 100 nanometers showed the functionality of these structures was qualitatively different from the functionality of the structures which had bigger sizes of the particles of the material.

After decreasing the linear sizes of elements of the electronic schemes to some ones or tens of nanometers, the technology of such semiconductor structures really becomes art. The nanometer scale makes it necessary to create variegated structures which limit of the division between two smooth components has the atomic scale [1,2,3,4].

Matrices of thermal sensors in the technology of MEMS

As it is known, the main advantage of thermovisional systems on the multielement thermal sensors compared with systems with photon and quantum sets is that it is not necessary to cool them down to the cryogenic temperatures for their work. The basis of the work of thermal sensors is not photon effects but changes of the features of the material which happen as a result of changes of the temperature of the sensor under the influence of the falling radiation. The analysis of the work of the thermal sensor can be made on a basis of its functional scheme (Fig 1.).

It includes a sensitive element (*pyroelectric, bolometer, thermopair*) by the general thermothroughput Q which is connected by the thermal bridge to the thermothroughput H and the thermotap at the fixed temperature T.

As the thermal equability of time t_T is defined by the relation of the thermocapacity to the thermothroughput, the thermothroughput of the thermal sensor has to be small enough. In case the area of one order detector element is 50x50 μm^2, it is necessary to decrease the thickness of the thermal sensor until micron sizes to be able to work in the full frame mode. In this case the ability of temperature to some hundredths of a degree Kelvin is ensured by the general thermothroughput of the construction of the matrix element with some tenths of a microwatt for a degree.

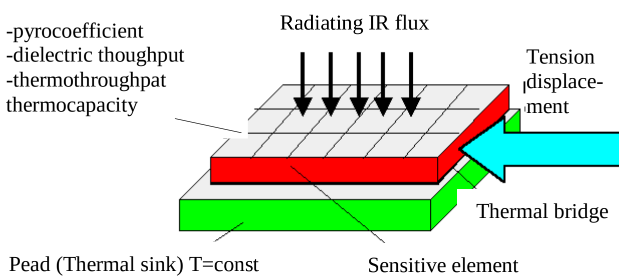

Fig. 1. Thermal sensor functional scheme

Today it is possible to indicate the main materials which have the best complex characteristics for recipients UFPA (Uncoded focal plane arrays):

- pyroelectric ones [5-7] (*plumbum circonate, barium-strontium niobate and titanate, vinylidenftoride sopolymers*) whose changes of temperature are defined according to changes of polymerization or dielectric throughput of the detector condenser element;

- materials for microbolometers [8] (modification of vanadium oxides VO_X, polycrystal and amorphous silicon) with a big meaning of the temperature resistance coefficient (TRC).

The thermothroughput of the elements of the construction Q = 5 x 10^6 Bm/K (area of the element 50x50 μm^2) was reached for the first serial examples of multielement hybrid matrix thermal sensors. However, the technology of the hybrid assemblage, thin plates of segnetoelectric (barium- strontium titanate) and crystal with ROIC (Readout integrated circuits) (Fig 2.) does not allow to essentially improve indexes of thermoinsulation.

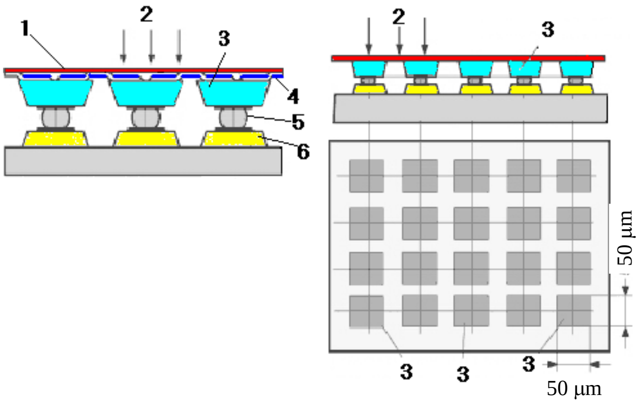

Fig. 2. Thin segneto electric plate hybrid assembly scheme: 1 – Absorption layer, 2 – IR radiation, 3 – segneto electric cell, 4 – electrode, 5 – solder, 6 – polymeric thermo insulator

Besides, the workers mentioned the workability of the operations like making a plate from segnetoelectric ceramics of the thickness 20…30 μm, its division into matrix elements of detectors of the sizes 50x50 μm^2 and especially connecting matrix elements with the crystal ROIC by thermoinsulation and electro-conductive columns, was low.

The analysis of processing thermovisional systems indicates the main factor of success to create matrices of full frame multielement thermal sensors and thermovisors according to them is implementation of MEMS (MicroElectroMechanical Systems) – a microelectro-mechanical technology which is widely applied to create various microminiature constructions in silicon crystals.

It is made by deep alloying of silicon or by special putting an auxiliary protective layer from polyamamide, phosphor silicate glass (PSG-Phosphor Silicate Glass) or polysilicon on its surface. There is a complex in Fig.3.

Elements of the sensor are made from the film of the thermo-sensitive material in the form of the lifted square with the side of 50 μm which rests on the crystal at the two opposite angles.

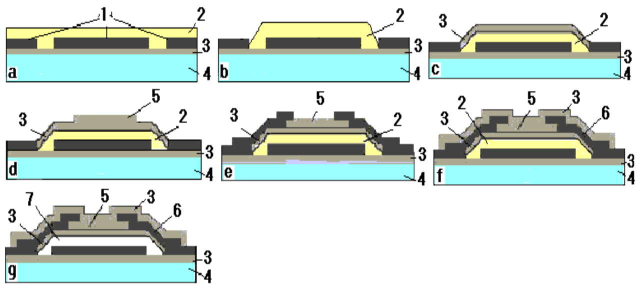

Fig. 3. Entity of technological operation for getting thermoisolated surface of MEMS structure for integral thermo sensor: a – Coating with protective layer from polemid varnish; b – Topology formation of protective layer: c – Coating and formatting of carrying layer Si N plasma-stimulation of chemical precipitate in a steam phase, photolithography; d – Precipitate film VO_2 and formation of topology: coating, photolithography e – Manufacturing of metal electrodes: vacuum coating, end of photolithography f – Coating and formation of surface layer Si_3N_4: plasma stimulation of chemical precipitate in a steam phase, photolithography; g – Cleaning of polemid protective layer, where 1 – Au, 2 – polemic, 3 – Si_3N_4, 4 – Si, VO_2, 6 – metal electrodes, 7 – empty space

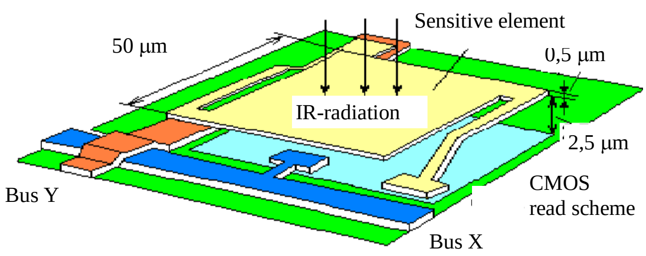

Fig. 4. Typical construction of matrix-thermal sensor‘s grating

Usually the material of the sensor itself is an absorbent interferential four-waved layer or such a layer is formed on the surface of the sensor.

An effective absorbent of radiation in the distant IR range is a layer Si_3N_4 which is usually used as a carrying basis of the thermo-sensitive film. The surface of the absorbent layer is covered by a thin layer of metal which resists to the reflection of IR radiation, the order resistance is 177 Ω/m.

Pyrosensors are temperature-sensitive. If we want to get the qualitative characteristics, it is necessary to stabilize the working temperature of the matrix. The elements of Peltier are usually used for this purpose and they are located in the hermetical body of the recipient. The recipient has a window which is transparent for the working range of waves (Fig. 5.).

With the help of MEMS technology, non-cooled thermal sensors are processed according to the structure silicon film-insulator-silicon “plate of the monocrystal” – SOI (Silicon-On-Insulator) where some subsequent p-n passes included are formed.

This set has a lower level of noises because of the high smoothness of the structure from two silicon layers of monocrystals divided by the insulator from silicon oxide. The detection of IR radiation is implemented because of the temperature dependence of the directly eliminated diode (order *TKO* is 7% K). The high temperature insulation (8,2 x 10^{-8} WK) is reached by using methods of the range technology MEMS which eliminates silicon from the sensitive part of the sensor. There is a construction of the pyrorecipient in Fig. 6. which is based on the subsequent p-n passes included and the range MEMS technology.

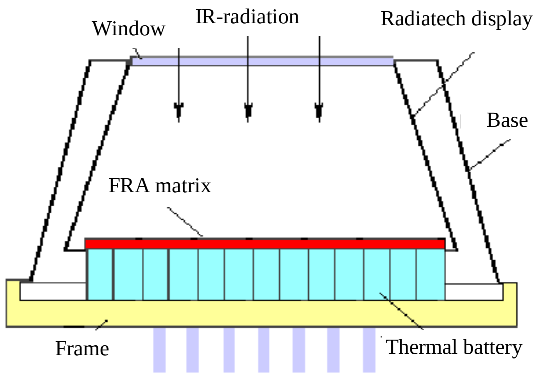

Fig. 5. Scheme of temperature sensitive pyrorecipient with transparent window for working range of waves

A big advantage of this construction is its full compatibility with technological processes for silicon.

Another kind of processing also based on the silicon technology is matrix sensors on the thermoelectric effect. This technology is related to the development of the MEMS technology.

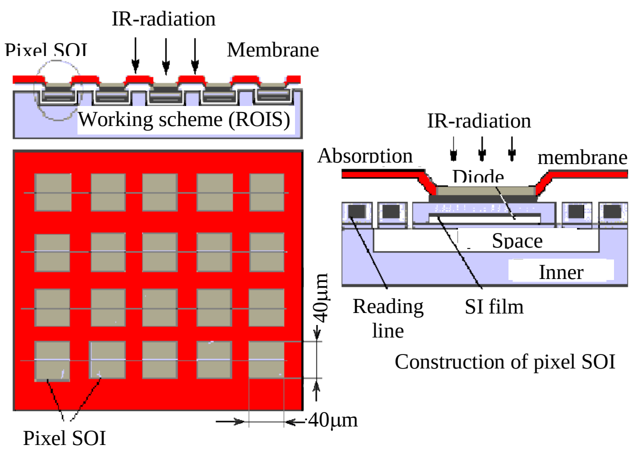

Fig. 6. Scheme of pyrorecipient with in series connected p-n transition for MEMS technology

The construction of the thermal sensor on the thermopairs is shown schematically in Fig 6.

The technology uses a standard *SMOS* process where high-alloyed ranges of the n- and p-types of semi-silicon are made on the membrane from silicon nitride and joined to the thermopairs by the aluminium lead.

Phosphor silicon glass (PSG) serves as a protective layer. Cold solder is put on the silicon backing. The thermoinsulation of the both solders is reached by the MEMS process, so a stripe etched by the help of hydrasive etching the backing to n-silicon is made under the membrane.

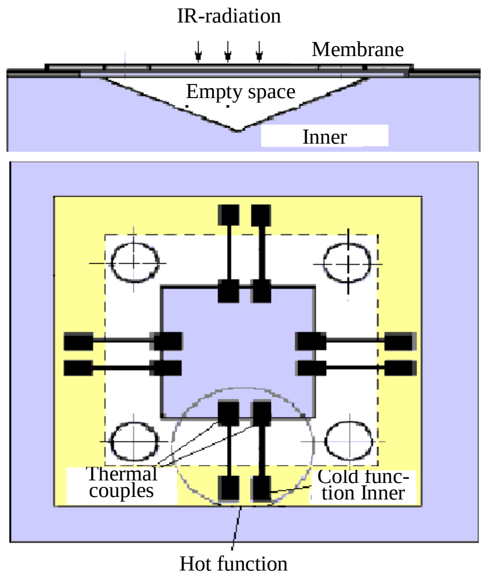

Fig. 7. Scheme of thermal sensor with thermal couples

Conclusions

Intensive development of superior technologies has become the basis to create the whole family of modern devices of the IR range. According to evaluations by the specialists [8, 9], next works of thermo-vision will be made to improve the devices already processed. A special attention will be paid to thermovisors on a basis of cooling focal matrices on the ground of solid solutions of cadmium tellurides and hydrargyrum tellurides, antimonoide indigo and quantum well infrared photo-detectuib, also of non-cooled microbolometer and pyroelectric matrices.

The workers of the IR systems pay a special attention to the trend of the MEMS – miniature industrial systems connected with chips which are exploited under conditions of acoustic emission and mechanical vibration.

The publications of the recent years give us a possibility to evaluate the power of this technological trend. The methodology of projecting new devices of the IR range in total and of sensitive elements in details to work under real conditions is also explored.

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Modern receivers operating on the basis of photonic and Quantum effects, the structure and manufacture technologies of such receivers are rewiewed in the paper. Principle schemes of IR system appled in MEMS and integrated with clips explaited in the condition of acoustic emission and mechanical vibrations are presented. The desing perspective of new devices operating in IR interval and of sensitive elements operating in real time. Ill. 7, bibl. 9 (in English; summaries in English, Russian and Lithuanian).

С. Муравов, С. Воронов, А. Богорош, Б. Ройзман, А. Бубулис. Микроузлы для приборов диагностики // Электроника и электротехника. – Каунас: Технология, 2008. – № 8(88). – С. 29–32.

Рассматриваются современные приемники на фотонных и квантовых эффектах, их конструкции и технологии изготовления. Приводятся разработки ИК систем применительно для MEMS, объединенных с чипами, эксплуатируемых в условиях акустической эмиссии и механической вибрации. Представлена перспектива проектирования новых приборов ИК-диапазона в целом и чувсвительных элементов в частности, работающих в реальных условиях. Ил. 7, библ. 9 (на английском языке; рефератыв английском, русском и литовском яз.).

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Apžvegti šiuolaikiniai imtuvai, veikiantys fotoninio ir kvantinio efekto pagrindu, jų konstrukcijos ir gamybos technologijos. Pateiktos IR sistemų pricipinės schemos, naudojamos MEMS, sujungtos su lustais, kurios eksploatuojamos akustinės emisijos ir mechaninės vibracijos sąlygomis. Aprašytos naujų prietaisų, veikiančių IR-intervale apskritai ir jautrių elementų konkrečiai, dirbančių realiu laiku, projektavimo perspektyvos. Il.7, bibl. 9 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).