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ABSTRACTS

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UNCOOLING GaAs "PYROELECTRIC" SENSOR

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Infrared semiconductor sensors use photoconductivity and need cooling. Modern uncooling IR sensors are based on pyroelectric effect in polar dielectrics but they should be integrated with silicon processor with amplifiers and read out electronics. Artificial pyroelectricity recently discovered in GaAs type semiconductors allow to design the one-crystal uncooling semiconductor "pyrosensor" in which transducer and amplifier are built up in a one crystal. Semi-insulating GaAs [111]-orientated wafer is thermal-to-electric transducer while amplifiers and other microelectronics is no more than very thin epitaxial layers with an ultra low thermal mass.

It was obtained that [111]-GaAs "pyrocoefficient" is 1.5 10 μC/m^{2}K and its voltage sensitivity is Sv = 0.02 m^{2}C^{-1} (that corresponds to PZT pyroelectric ceramics). Our investigations show that some of III-V semiconductors which are capable to form solid solutions with GaAs have Sv ten times more. Above all,they are much closer to dielectrics than semi-insulating GaAs.

New microelectronic device named "pyrotransistor" consists of MESFET with submicron channel that can be realized in the thin epitaxial layer deposited onto (111)-cut wafer operating as "pyrogate". The IR radiation could be absorbed as by special absorbent layer covering the back side of wafer-substrate so due to crystal internal absorption. The last could be explained by peculiarities of polar lattice, imperfections and doping.

The processes of carrier transfer in the epitaxial layer in the field effect structure is controlled by a thermoinduced electric field in wafer. In various constructions of sensor as longitudinal so transverse thermoinduced electric field was used. Produced by the charge carries diffusion into semi-insulating substrate from channel, the enrichment layer plays a crucial role in source-drain (S-D) conductivity if channel length is less then 1 μm. In the short channel MESFET the dependence of S-D conductivity on substrate potential is most pronouced due to variations of enrichment layer thickness. The last could be controlled by wafer`s internal electric field Ep. Moreover, this field changes channel length that in its turn controls a MESFET drain current.

Simulation predicts that realization of submicron field structure pyrotransistor is possible with following main parameters:

0.5 μm distance between drain and source electrodes;
0.2 x 500 um gate size;
0.06 μm thickness of epitaxial layer that has 4 10^{17} cm^{-3} doping level;
100 μm thickness of substrate=wafer with a 2 10^{14} cm^{-3} doping level.

This structure is possible to arrange over 50 x 50 μm^2 crystal area. Hundreds of pyrotransistors on the same wafer would form matrix thermal image processor which sensitivity increases as square root from cells number. The current status of microelectronics can guarantee the identity of each cell in this one-crystal pyroprocessor.

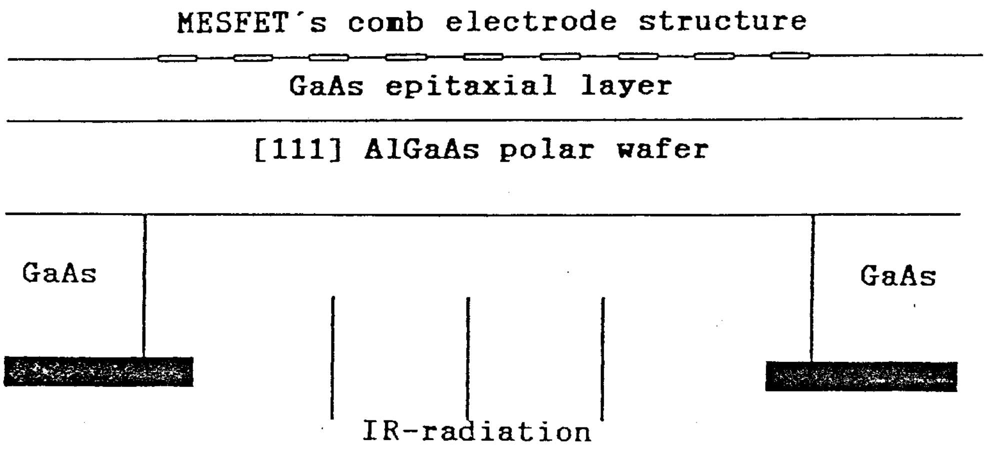

Fig.1. Cross-section of pyrotransistor's cell

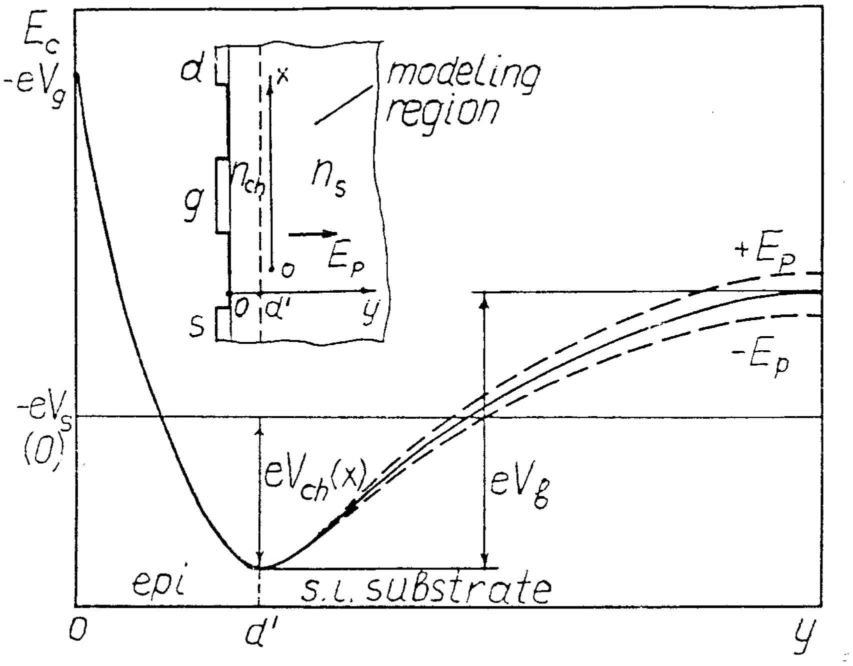

Fig.2. Potential shape in the under-gate vicinity of channel: s - sourse, g - gate, d - drain, d` -epitaxial layer thickness, Ep - pyroelectric field. MESFET contains of a high-level doped epitaxial layer deposited onto semi-insulated wafer=substrate. Submicron channel is located near the boundary epitaxial layer-substrate (that is in the vicinity of potential energy minimum). The last is formed by the back-biased Schottky barrier and by the contact potential barrier from substrate. Thermally induced response Ep is capable to change the potential barrier height and shape. The most profitable drain current control could be got near the threshold region of MESFET characteristics (if the gate potential is close to the pinch-off voltage). This mode of operation provides also the least noise factor of MESFET.