# Narrow-gap semiconductor as the all-ware detector from near IR to mm wave regions

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***Abstract*—Technology advances combined with physical properties of mercury cadmium telluride (MCT) empower its applications in IR and sub-mm technical vision systems. Properties of MCT detectors manufactured both for IR, mm and sub-mm (THz) regions are discussed.**

## I. Introduction

Mercury cadmium telluride (MCT) semiconductor today is a base material for quantum detectors sensitive from near IR ($\lambda \approx 1.5$ microns) to long IR wave region ($\lambda \approx 25$ micron) which is widely used in modern optoelectronics systems with ultimate performance. At the same time there are almost no researches on this material used for registration of electromagnetic radiation in mm and sub-mm regions. It was earlier shown the possibility to use MCT layers as ambient or moderately cooled detectors for mm and sub-mm radiation on the base of hot-carrier effect [1].

The possible ultimate parameters of IR heterostructure MCT arrays with readout electronics are discussed. The direct detection THz semiconductor hot electron bolometer (SHEB) is considered too and its model is developed. The device operation takes into account the phenomena in semiconductor bipolar plasma and hot-carrier effect at cryogenic temperatures. In this device the radiation heats only electron gas without the semiconductor lattice inertial heating. To examine the detector proposed in the wide range of operation frequencies ($\nu$=0.037–1.58 THz) in this SHEB, the simplest dipole antennas were used in the arrays of 10 elements. Because of this the detectors properties depend much on the wavelength and orientation of the electric field against the electric contacts long side.

## II. Results

Shortly the ultimate performance results of MCT traditional photovoltaic detectors for 3-5 and 8-14 µm spectral ranges are discussed. But mainly the purpose of this investigation was to consider an uncooled or slightly cooled direct semiconductor hot electron bolometer which can be used in wide mm and sub-mm ranges.

The experiments were performed at $T$ = 300 K at frequencies $\nu$= 37, 50, 75 GHz, and 0.89, 1.58 THz with a HgCdTe SHEB prototype device, with rather large and not optimized dimensions, as a rule, not used with mm and sub-mm detectors. At $\nu$=0.89 THz and 37 GHz the signal temperature dependencies were measured too. For latter one this dependence is shown in Fig.1.

Calculated from this dependence the sensitivity $S$ is phase dependent. The response was lowered at near 260 K and passed through zero at approximately 130 K. At that temperature the sign of response is changed and is determined by hot carrier transport mechanism changes. Then the sharp rise of signal (up to two orders at temperature 78 K) was occurred. The measured value of sensitivity was $S_V \sim 2.6$ V/W (NEP$\sim 3.5 \cdot 10^{-10}$ W/Hz$^{1/2}$) at $T$=300 K and $S_V \sim 1.3 \cdot 10^3$ V/W (NEP$\sim 10^{-12}$ W/Hz$^{1/2}$) at $T$=78 K. The signal temperature dependences at $\nu$=0.89 THz are different and has signal maximum at T≈190 K. The sign response change takes place approximately at the same temperature.

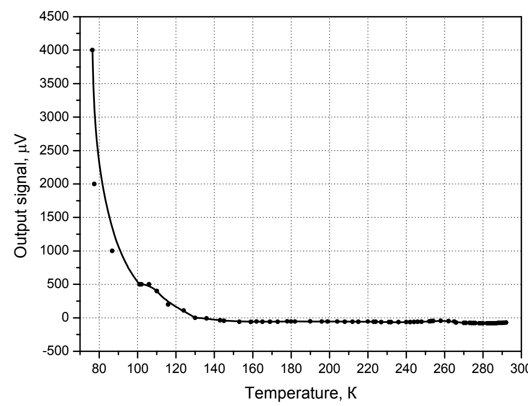


Fig.1. Temperature dependence of the output signal for one of the sensitive elements of $Hg_{1-x}Cd_xTe$ (x~0.2) microbolometer

A theoretical model of the detector signal occurrence is developed. The electric field and electron/hole concentration changes in the heated plasma are the reasons of this signal. The radiation entrance through the free semiconductor surface and the metal contacts are modeled both.

The results obtained are compared with the parameters of another new sub-mm uncooled detector – two-dimensional plasmon modes HEMT structure detector[2].

## References

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