Abstract

A novel MEMS thermopile structure is presented, which consist of linearly arranged p- and n-type polysilicon strips instead of the conventional loop-like configuration. It is shown that these devices sense the millimeter wave radiation beyond the infrared. The polarity and frequency dependence of the sensitivity prove that these strips behave as absorbing antennas towards the microwave/millimeter wave radiation. The measured responsivities to direct heating, infrared radiation, 13 GHz microwave radiation, 100 GHz millimeter-wave and THz radiation are presented.

Keywords: THz; Millimeter wave; Thermopile; Antenna

1. Introduction

The THz region is the last unexploited part of the electromagnetic radiation. Its position within the spectrum is shown in Fig. 1.

Recently there is an enhanced interest in the THz and mm wave radiations due to the possible applications. This radiation “sees” through the clothing, bags, etc. Also the non-metallic objects can be sensed, moreover identification of drugs, explosives, etc. is possible through their spectral absorption. The motivation of the present work is to construct a THz detector which is suitable for integration into a matrix and is quick enough for real-time imaging.

2. The device

We have proposed [1] a linearly arranged micromachined thermopile structure for THz detector, see Fig. 2. The thermopile strips act as short-circuited dipole antennas, the high-frequency electric field parallel to them induces current...
Fig. 2. The thermopairs are formed from p- and n-doped polycrystalline Si strips grown on the non-stoichiometric silicon-nitride (SiNₓ) film. The substrate is crystalline Si wafer, it is removed from the middle region. The strips are 10 µm wide and 0.5 µm thick with 10 µm spacing between them.

and associated Joule heating in them. The distribution of the current is sinusoidal, having the maximum value at the centre and zero at the ends of the lines, therefore the maximum of the heating occurs at the hot end of the thermopairs. The devices were fabricated by the combination of a conventional poly-silicon thermopile technology and double side bulk silicon micromachining.

The responsivity at infrared radiation and 100 GHz was found to 20 V/W and 5.58 V/W respectively [2]. In broadband THz, where the radiation was generated by a ps pulse, 21 V/W was obtained. The relaxation time was estimated by pulsed electric heating, it was 9.3 ms.

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References