Low Temperature Operation of a Microbolometer Array for Terahertz Detection

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1. Abstract

In this work we present the design and characterization of a microbolometer array for detection of radiation in the 0.7-1.5 THz frequency range. Our study shows that the microbolometer array can operate from 77 to 350 K. The sensing film is made of a boron-doped hydrogenated amorphous silicon film, which was deposited on a cavity-suspended silicon nitride membrane forming a 5x5 array. We obtained a higher temperature coefficient of resistance (TCR) than those values reported in the literature. The current–voltage characteristics present an ohmic behaviour.

2. Introduction

The development of IR detectors began in 1821, when Thomas J. Seebeck discovered the thermoelectric effect; since then, many types of detectors have been used extensively in the far-infrared (FIR) and sub-mm applications, between 100 µm and 1 mm [1, 2]. Infrared sensors, thermopiles, pyroelectric devices and thermistor bolometers are examples of such detectors. In particular, bolometers are used for astrophysical application at millimeter wavelengths and in the health sector [3]. Sensing and imaging using pulsed terahertz (THz) radiation have been widely recognized for reconstructing three-dimensional (3-D) images [4-6]. THz falls between the radiofrequency (RF) and infrared (IR) bands and is a largely unexploited region of the electromagnetic spectrum. Some materials commonly employed as micro-bolometer sensor layers are vanadium oxide (VOx), polycrystalline silicon, germanium and high resistivity hydrogenated amorphous silicon (a-Si:H) [7-8]. Among them, one key issue for achieving low-cost detectors and monolithic construction is their easy integration and compatibility with the CMOS technology. In this work we present the performance of a boron doped a-Si:H microbolometer array operating from 350 K down to liquid nitrogen temperature.

3. Bolometer performance

A resistive bolometer is a thermal detector in which the variation in the electrical resistance is used to determine a change in temperature caused by the absorbed radiation. The radiation is absorbed on the sensor surface leading to a temperature increase and a resistance change (fig. 1).

The change in resistance is sensed using a current bias voltage-divider circuit.

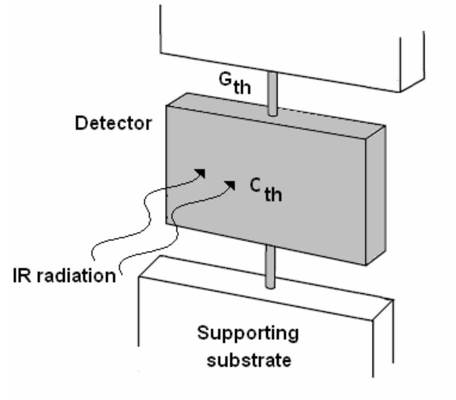

Fig. 1 Simplified bolometer layout.

3. Experimental results and discussion

We have fabricated and packaged an array of bolometers made from boron doped hydrogenated amorphous silicon (a-Si-B:H). The bolometer sensing layer is a 95 nm-thick a-Si-B:H film grown using an AMP 3300 PECVD (plasma-enhanced chemical vapor deposition), which is a conventional capacitor coupled parallel-plate reactor. The RF frequency of the power supply was set at 110 KHz and the deposition temperature was set to 540 K. The a-Si:B:H layer was deposited on a silicon nitride (Si_3N_4) membrane sustained by a micromachined crystalline Si substrate, in order to obtain thermal and electrical isolation. The Si_3N4 also works as the IR absorber material. The c-Si wafer was micro machined using a potassium hidroxide (KOH) solution at 354 K for 6 hours. The 350 nm-thick Si_3N_4 film was deposited using the low pressure chemical vapor deposition (LPCVD) technique. The bolometer array is shown in figure 2. It consists of a 5x5 square array. Each bolometer was individually wire-bonded for electrical measurements.