Characterization of a hydrogenated amorphous silicon microbolometer array

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ABSTRACT

We present the characterization of a boron doped hydrogenated amorphous silicon (a-Si:H) thermosensor bolometer array for far infrared detection. The array was fabricated over a silicon wafer on a 0.4 µm silicon-nitride (Si_3N_4) layer. Wet bulk micromachining was used to create pixels of suspended nitride film by removing the silicon underneath. On this film, a boron doped a-Si:H layer was deposited using a low frequency PECVD system at 540 K. Conventional lithography was used to define the bolometers on the nitride windows, and the 5 x 5 microbolometer array was fabricated and characterized at 77 K. A 1.17 x 10^{-2} mA/W responsivity, with a temperature coefficient of resistance (TCR) of 4.25%, were obtained.

Keywords: Hydrogenated amorphous silicon, thermosensor, microbolometers.

1. INTRODUCTION

Since the 1950´s infrared (IR) imaging system technology has been developed for several applications in astronomy [1], medical examination [2] and a wide variety of civilian and military applications [3]. Sub-mm applications have been developed for imaging between 100 µm and 1 mm [4,5] using cameras based on transition edge sensors (TES) bolometer arrays. Sensing and imaging using pulsed terahertz (THz) radiation has also been recognized for reconstructing three-dimensional (3-D) object image [6,7].

The development of IR detectors starts with the development of thermal detectors in 1821, when Thomas J. Seebeck discovered the thermoelectric effect; since then many types of detectors have been used extensively for the far-infrared (FIR) detection. Vanadium oxide (VOx), polycrystalline silicon, germanium and hydrogenated amorphous silicon (a-Si:H) are materials commonly employed for micro-bolometer sensors [8-10]. Most of these detectors present a very high resistivity. One key issue for obtaining low-cost detectors using monolithic construction is their easy integration and compatibility with CMOS technology. The development for different kind of bolometers array in conjunction with the silicon fabrication technology and micromachining techniques have paved the way for low cost and large format IR imaging devices. In this paper we present the characterization of a 2D array of bolometers made of boron doped hydrogenated amorphous silicon (a-Si-B:H) as the material sensor operating at 77 K.

2. BOLOMETER PERFORMANCE.

Resistive bolometers, thermopile detectors and pyroelectric detectors are different types of thermal detectors. Resistive bolometers have demonstrated good thermal isolation, higher responsivity than thermopile detectors, and are generally easier to integrate in device structures than pyroelectric detectors. Read-out integrated circuitry (RIOC), employing micromachining processes, is an additional advantage of using resistive microbolometers. Additionally, they do not require mechanical choppers to modulate the scene, thus offering lower manufacturing costs depending on its operation.

An ideal (or simple) thermal detector is formed by a temperature dependent resistor and an IR absorber. The bolometer has a thermal capacity C_{th}, and it is connected to an infinite heat sink at a temperature T_o through supports having a thermal conductance G_{th}. The absorbed IR radiation increases the temperature of the bolometer to T. In order to maximize the temperature increase, the bolometer must be thermally insulated. The use of micromachining techniques has allowed for reducing the thermal conductance of the device to values close to the radiation limit [11].

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