The Millimeter-Wave Detector Using Vanadium Oxide with Planar Structure Antenna

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***Abstract*—We have developed a new millimeter-wave detector. The detector consists of a micro bolometric detecting part, a micro heater and a micro antenna. Vanadium oxide thin film was deposited for thermal detecting materials. The micro log-periodic bow-tie antenna having resonance frequency of 140GHz was designed and simulated. The antenna coupled detectors were fabricated by MEMS technology. The fabricated detector showed resonance frequency of 140GHz which is the same as simulation result and large TCR value of 4%.**

I. Introduction

IMAGING techniques have been developed at various electromagnetic wave frequency bands including X-ray, UV, and infrared. In addition, millimeter-wave (MMW) image sensors are currently being studied due to its several characteristics. MMW can pass through some objects and propagate with significantly less attenuation under low-visibility conditions than infrared and visible radiation. Furthermore, MMW is less affected by atmospheric conditions. For these reasons, MMW detectors can be applied in a variety of areas including radio astronomy, atmospheric radiometry, concealed weapon detection, all-weather aircraft landing and through-wall imaging [1]-[2]. In this paper, we present the new antenna coupled MMW detector using vanadium oxide.

II. Experimental

The new millimeter-wave detector using vanadium oxide thin film as a thermal detecting material has been developed. The detector consists of a micro bolometric detecting part, a micro heater and a micro antenna. Vanadium oxide thin film was used for thermal detecting material due to its large temperature coefficient of resistance (TCR). The micro heater was fabricated using polysilicon. The micro log-periodic bow-tie antenna having broadband characteristic was applied for the antenna coupled detector. The antenna with planar structure and resonance frequency of 140GHz was designed and simulated. Fig. 1 shows the new designed log-periodic bow-tie antenna. The antenna coupled MMW detector was fabricated on a 4inch silicon wafer by MEMS technology. The schematic of fabrication process is illustrated in Fig. 2. The polysilicon layer was deposited by LPCVD and patterned for the micro heater. After insulation between heater and detecting material, the vanadium oxide thin film was deposited by reactive DC magnetron sputter. The antenna based on simulation results and electrodes are fabricated using a metal layer which was coated by e-beam evaporator. Lastly, Backside-etching of the silicon substrate except membrane was carried out for thermal isolation structure. TCR value which is closely related to sensitivity of the detector was measured. BWO (Backward Wave Oscillator) spectroscopy was used for investigation of frequency characteristics of the fabricated detector.

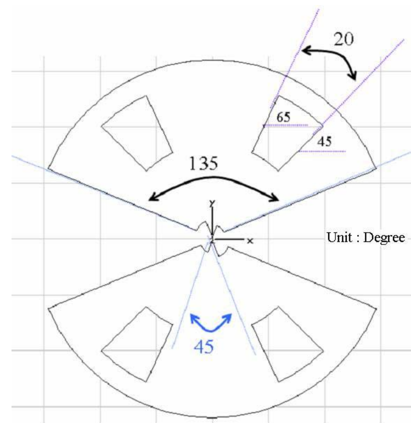

Fig. 1. Schematic diagram of the designed log-periodic bow-tie antenna.

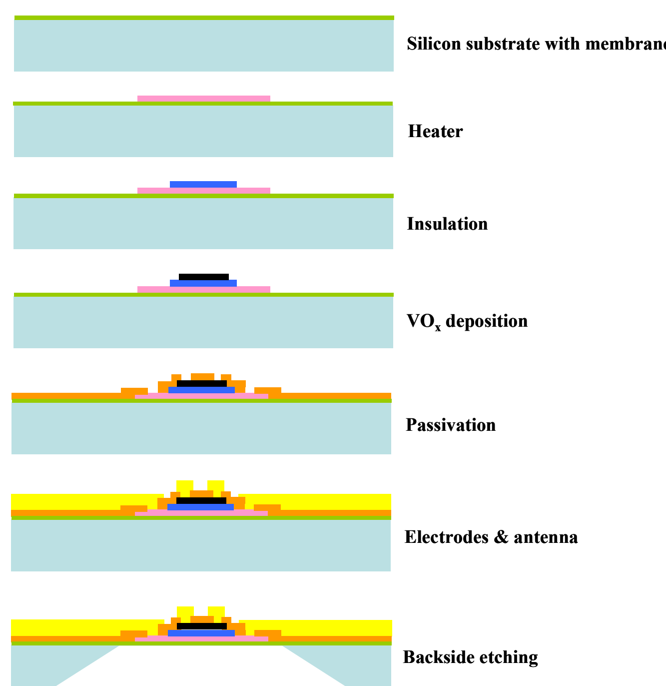

Fig. 2. Fabrication process of the MMW detector.

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III. RESULTS

Fig. 3 presents the result of frequency simulation. As a result of the antenna simulation, the designed log-periodic bow-tie antenna has resonance frequency of 140GHz and shows broadband characteristic of 31.6GHz (118.1GHz ~ 149.7GHz). Fig. 4 shows the photograph of the fabricated detector. The single cell of the detector has small size of 3mm by 3mm.

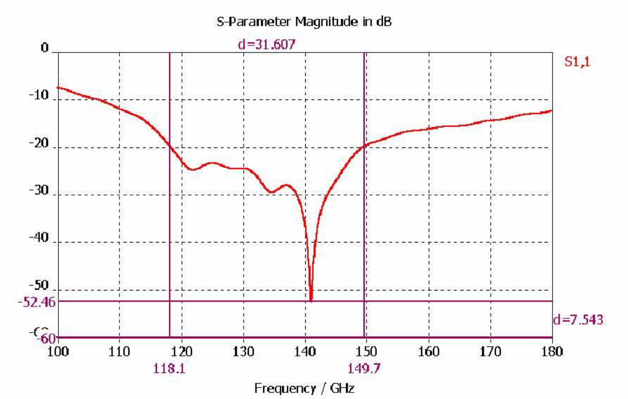

Fig. 3. Simulation output of the designed log-periodic bow-tie antenna.

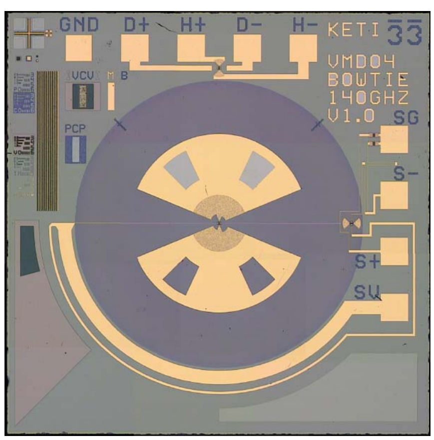

Fig. 4. Single cell of the fabricated MMW image sensor of which size is 3mm by 3mm.

In Fig. 5, the measured resistance value of the fabricated detector is exhibited as a function of temperature. The calculated TCR value of the detector is 4.0% around room temperature which is high enough to be used for thermal detector. The frequency characteristics of the detector are shown in Fig. 6. The relative sensitivity was measured as the frequency increased from 120GHz to 175GHz, showing largest value at 140GHz which is the same frequency as that of simulation result.

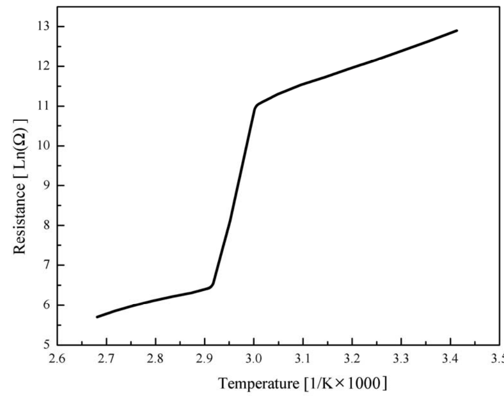

Fig. 5. Measured detector output as a function of temperature.

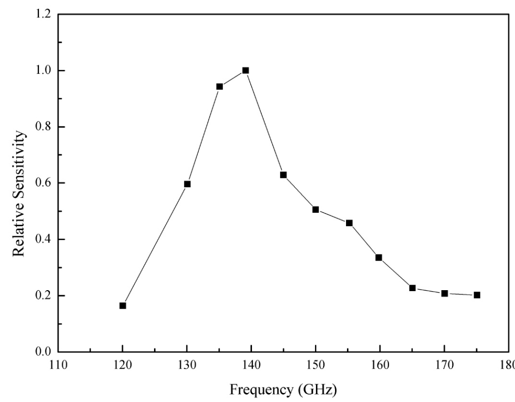

Fig. 6. Frequency characteristic of the detector.

IV. CONCLUSION

The new MMW detector using vanadium oxide with planar structure antenna has been developed. The designed and simulated detector was fabricated by MEMS technology. The fabricated detector showed resonance frequency of 140GHz which is the same as simulation result. The measured TCR value was 4.0% and it is sufficient to be used for thermal detector. Based on these results, we expect that suggest detector will be applied in MMW-imaging system.

ACKNOWLEDGEMENTS

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