A 0.6 THz Quasi-Optical Detector Based on a room microbolometer

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***Abstract*— This paper reports the performance of a THz detector with a wide bandwidth based on Nb_5N_6 microbolometer operated at room temperature. This microbolometer integrated with a planar folded dipole antenna is fabricated on the high resistance Si substrates. The best attainable electrical responsibility of Nb_5N_6 microbolometer is about -600 V/W. A quasi-optical type detector based on this Nb_5N_6 microbolometer is constructed, and the result shows a good performance at a range of 0.6THz to 0.7THz.**

I. INTRODUCTION

Terahertz detectors have a wide range of applications in nondestructive evaluation of materials, security checks, astronomical observations, and bio-sensing etc [1-3]. Characteristics of the detector performance indicators are: the noise equivalent power (NEP), the response time, the operating frequency and operating temperature. The noise equivalent power (NEP) can be expressed as

$$NEP = S_v / \kappa_A \qquad (1)$$

where $\boldsymbol{S}_v$ and $\boldsymbol{\kappa}_A$ are the voltage noise spectral density (V/Hz$^{1/2}$) and responsivity of the detector, respectively. Therefore the sensitivity and the operating frequency determine the applications of a detector. Thanks to Nb_5N_6 thin film, which is of a high temperature coefficient of resistance (TCR = $1/R\cdot dR/dT$=-0.7%) K^{-1}) and low noise. A low noise detector based on Nb_5N_6 microbolometer integrated a dipole planar antenna has been successfully developed for 0.22 THz working at room temperature [3]. Even though this detector have a high responsivity at 0.22THz, due to the design of high impedance match between the Nb_5N_6 microbolometer and dipole antenna, the frequency bandwidth is limited.

Here, we will present the design and fabrication of a low noise, broadband Nb_5N_6 quasi optical detector for detecting 0.6THz signal.

II. THE ANTENNA DESIGN OF DETECTOR

Nb_5N_6 thin film is deposited on a high resistance Si substrate (ρ> 1000 Ω·cm) with a SiO_2 thin layer with a thickness of 100 nm using the radio frequency (RF) magnetron sputtering. A 100 nm thick Nb_5N_6 thin film, the typical sheet resistance $\mathbf{R}_\square$ is about 700 Ω at 300K. It is well known that the input impedance of a conventional broadband self-complementary antenna is below 100 Ω . In order to match the high resistance of Nb_5N_6 thin film and obtain a wide operated bandwidth, we choose a folded dipole antenna in the new detector design, as shown in fig.1.

A folded dipole antenna with high input impedance has been reported previously [4]. There are several parameters to optimize for gain high impedance: ***W*** width of line, ***L*** length of line, ***d*** distance between lines, and ***N*** number of lines. As shown in fig.1,

$$L_1 = \frac{\lambda_{g1}}{2} = 139\mu m \ , \quad L_2 = \frac{\lambda_{g2}}{2} = 195\mu m \ , \quad W, d = 7\mu m \ ,$$

are selected in an attempt to get a rather good impedance match and wide band. We simulate its impedance vs frequency properties and electromagnetic field distributions using Software HFSS. As shown in Fig.2, there are two resonant frequencies at 0.615THz and 0.674THz respectively, corresponding to the real parts of 590 Ω and 580 Ω respectively.

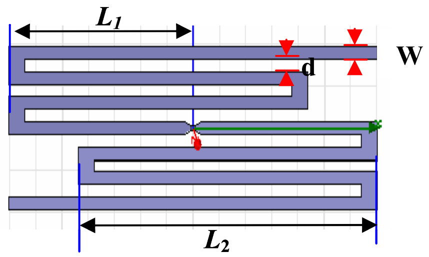

Fig. 1. The antenna design sketch of Nb_5N_6 bolometer

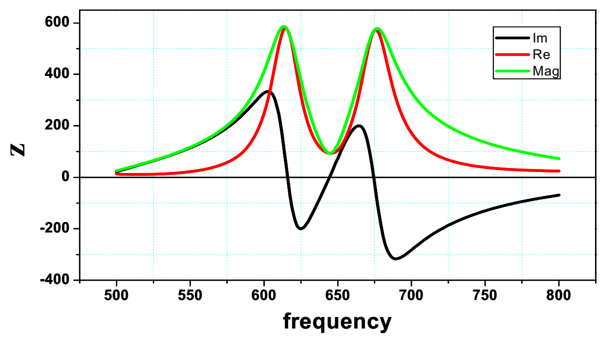

Fig. 2. The antenna's impedance vs frequency simulated by HFSS.

III. RESULTS

According to the design above, we fabricated Nb_5N_6 microbolometer and construct a quasi-optical type detector based on Nb_5N_6 microbolometer. The electrical responsibility $\boldsymbol{\kappa}$ we calculated by the I-V curve of our Nb_5N_6 microbolometer is around -600 V/W. In the frequency range of 0.6THz to 0.7THz, the measured responsivities of the detector lie in about -200 V/W. Besides, the other performances of Nb_5N_6 detector such as NEP, the response time will be discussed in detail later.

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