Terahertz detectors based on the room temperature Nb_5N_6 microbolometers

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Terahertz (THz) detectors based on the room-temperature (RT) microbolometers consisting of a Nb $_5N_6$ thin film microbridge and a dipole planar antenna are reported. Due to the high temperature coefficient of the resistance(TCR), which is as high as -0.7% K^{-1}, of the Nb_5N_6 thin film, such an antenna-coupled microbolometer is quite suitable for detecting THz signals. Previously, THz detectors working at 0.1 THz have been reported [1]. Here, the properties at 0.22-0.33 THz will be presented.

The microbolometers consist of a gold dipole planar antenna and a microbridge, which is the core element and is made of properly patterned Nb_5N_6 thin film. To effectively couple the applied THz power onto the Nb_5N_6 microbridge, a resonant dipole antenna is used. The dipole antenna is inserted into a 120 µm by 210 µm stub, which is also used to connect to the bias circuits. The software named HFSS is used to carry out numerical simulations for this antenna structure and to optimize the sizes. In the process of Nb_5N_6 microbolometer chip fabrication, a SiO_2/Si (100) combination substrate is used, where SiO_2 with 100 nm thick, is deposited by thermal oxidation on Si(100) substrate with high resistivity ($\rho > 1000\ \Omega\cdot$cm). Such a combination is chosen because of its low loss at lower band of THz frequencies and ease of fabricating an air-bridge, underneath the Nb_5N_6 microbridge. Then, we used radio frequency (RF) magnetron sputtering to deposit a Nb_5N_6 film (120 nm thick) on the substrate. The film was patterned into microbridges using photolithography and reactive ion etching (RIE). The dipole antenna was then integrated with the Nb_5N_6 microbridge by depositing a 5-nm-thick aluminum film firstly, a 220-nm-thick gold one later, and then pattern the antenna into the right shape and size as designed by the software. Finally, an air-bridge, which reduces the effective thermal conductance of the substrate to further enhance the responsivity, was formed under the Nb_5N_6 microbridge by etching 1 µm of the Si part of the SiO_2/ Si (100) combination substrate.

The DC responsivity at RT, calculated from the measured current-voltage (I-V) curve of the Nb_5N_6 microbolometer, is about -760 V/W at the bias current of 0.19 mA. A typical noise voltage as low as 10 nV/√Hz yields a low noise equivalent power (NEP) of 1.3×10^{-11} W/√Hz at modulation frequency above 4 kHz. The best RF responsivity at 0.28 THz, characterized using a normail measuring method for the infrared devices, is about 580 V/W, with the corresponding NEP being 1.7×10^{-11} W/√Hz. In order to further test the performance of Nb_5N_6 microbolometer, we constructed a quasi-optical type receiver by attaching it to a hyperhemispherical silicon lens and the result shows that the best responsivity of the receiver is about 320 V/W at 0.24 THz, which corresponding the NEP of 3.1×10^{-11} W/√Hz.

Using above detectors, an active imaging system at 0.22 THz has been constructed using a Cassegrain reflector with the diameter of 30 cm. The special resolution of about 1.41 cm is obtained. Also, this work could offer a candidate to develop a large scale focal plane array (FPA) with simple technique and low costs. The details will be discussed in the presentation.

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References

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