Room temperature Terahertz hot electron bolometric detector based on AlGaAs/GaAs two dimensional electron gas

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***Abstract*— in this paper, we present a hot-electron bolometric detector, which uses the nonlinearities of the heated two-dimensional electron gas medium in AlGaAs/GaAs at room temperature. The cooling process of the electrons is through the phonon-scattering mechanism. The response was measured at the 0.1 – 0.2 THz frequency range. The response was estimated, showing possible application of these detectors in sensing of Terahertz radiation.**

I. Introduction And Background

Hot-electron bolometers (HEBs) have recently demonstrated much lower receiver noise temperatures in the terahertz (THz) frequency range than have been possible with other types of devices. [1]. Hot electron detectors employing a nonlinear (electron) bolometer device was suggested by Yang et al.[2-3], (see also Yngvesson et al, [4].) In a hot electron bolometer, the electron-electron scattering time is much shorter than the electron-phonon scattering time. Consequently the electron gas has a temperature *Te* which is greater than the lattice temperature under the effect of a dc bias. The electrons are further heated by suitably coupled terahertz radiation, and the resulting change in electron mobility generates a voltage across the device which is proportional to the terahertz power absorbed. The heat capacity of the hot-electron bolometer *Ce* is that of the electrons and is very low, so the response time can be short.

In this letter, we report the experimental results of the terahertz response of a hot electron bolometer constructed using an AlGaAs/GaAs heterostructure. In considering an application driven antenna design we have chosen a twin slot geometry with length La= 0.32λo, separation Sa = 0.16λo and width W=0.05λo, where λo is the free-space wavelength. Several similar antennas were investigated.

The fabrication process was conventional for this material. Ohmic contacts are constructed by deposition of an alloy with subsequent annealing at a temperature of approximately 400°C, followed by mesa isolation, then passivation of the wafer with 200 nm thick SiO2. Finally, the twin slot antenna over the mesa was deposited by using an alignment mask. The inset of the Fig. 1 shows a schematic of a device designed for 425GHz. A similar design is reported in the literature at various other frequencies [5]. The samples were mounted on a hyper-hemispherical silicon lens to couple in the radiation.

II. Results

The devices were then placed in a cryostat behind an HDPE vacuum window and multi-mesh THz filters to control the signal input bandwidth. The signal response to input terahertz radiation was measured as a dc voltage on the open ohmic contact as a function of applied current. The second ohmic contact was grounded. A BWO source was used at 160GHz. Fig. 1 shows the response ΔV of two HEBs as function of the applied current. The HEBs were designed for 400GHz (black curve) and 600GHz (red curve).

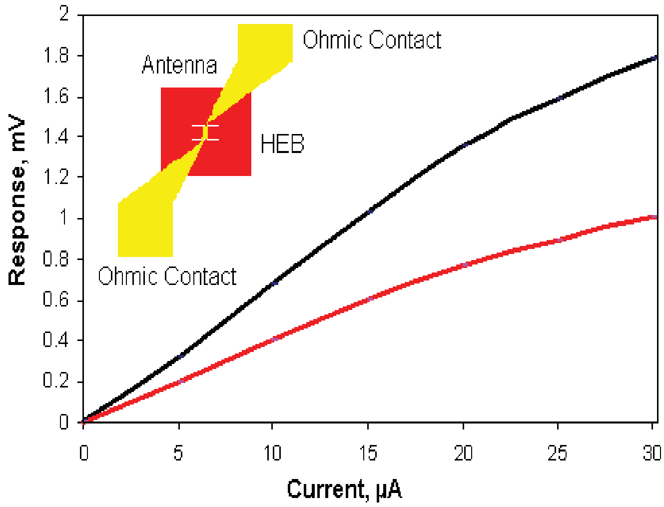

Fig.1: THz response of AlGaAs/GaAS HEBs versus applied current at room temperature and 160GHz for 400GHz(black) and 600GHz(red) devices. Inset: schematic of the device layout.

III CONCLUSION

We have produced a room temperature hot electron bolometer using conventional processing and demonstrated their efficient detection at terahertz frequencies. The response of these detectors amounts to about 2mV for noise level of $80nV/Hz^{0.5}$, showing possible application in terahertz imaging application.

References

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