TERAHERTZ DETECTION WITH AlGaN/GaN BOW-TIE DIODES AT 300 K AND 80 K TEMPERATURES

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Imaging with terahertz (THz) radiation is appealing due to its non-ionising nature and transparency of many common industrial materials in the frequency range of 0.1 – 30 THz. However, many aspects of generation [1-2] and detection [3-4] of THz radiation are still under extensive research. A compact and sensitive THz detector with a fast response time is highly desired for the THz imaging systems.

In this work we investigate the performance of AlGaN/GaN bow-tie (BT) diodes as THz detectors in sub-THz frequency range at temperatures of 300 K and 80 K. The BT diodes were fabricated of $Al_{0.25}Ga_{0.75}N$/GaN high electron mobility transistor (HEMT) structures grown on semi-insulating SiC substrate [5]. A two-dimensional electron gas (2DEG) concentration $N_{2DEG} = 9.4\cdot10^{12}$ cm^{-2} and mobility μ = 1800 cm^2/V·s was found at 300 K from Hall experiment. At 80 K, these parameters changed to $N_{2DEG} = 8.6\cdot10^{12}$ cm^{-2} and μ = 15830 cm^2/V·s. Ohmic contacts were formed from Ti/Al/Ni/Au stack annealed at 830 ºC for 30 s at nitrogen ambient. The resistivity of ohmic contacts was determined using transfer length method, providing values of less than 1 Ω·mm independent on temperature in the range of 300-80 K. For electrical isolation, a 700 keV energy Al^+ ions were implanted into $Al_{0.25}Ga_{0.75}N$/GaN HEMT structures [6].

Operation of the BT diode, as a THz detector, relies on a non-uniform heating of carriers in the apex of geometrically shaped 2DEG layer under antenna-coupled electric field. Detection was studied using a quasi-optical illumination setup based on electronic multiplier chain source (VDI). Signal from detector was recorded using lock-in amplifier. Fig. 1 shows 2D profiles of 150 GHz Gaussian beam recorded with the 5 µm apex-width BT diode integrated with a hemispherical Si lens. The detected signal without applied bias was of 433 µV at the 300 K. An external bias of -0.8 V increased the signal by 20 dB resulting in the decrease of the noise equivalent power (NEP) from 249 to 4 nW/√Hz under assumption that the Johnson noise dominated in the measurements. Further signal increase is expected at 80 K due to the increase of 2DEG mobility.

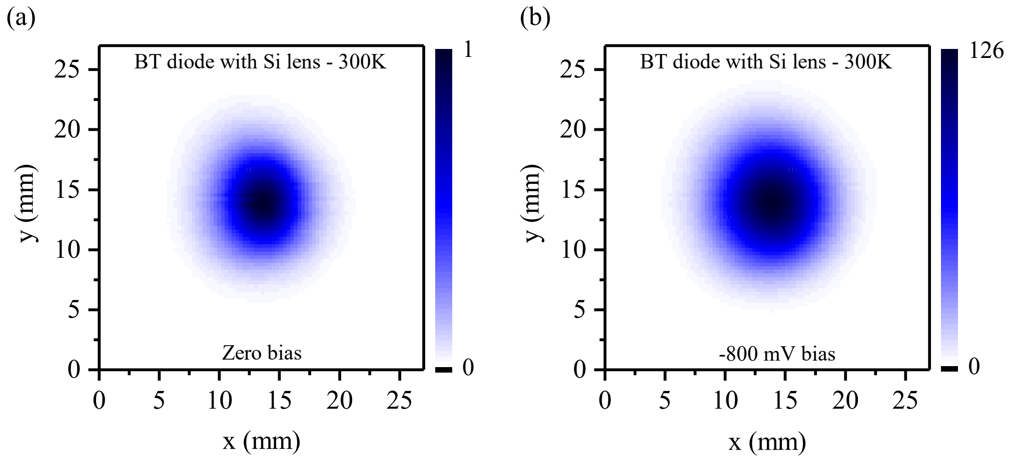

Fig. 1. Images of 150 GHz Gaussian beam recorded with BT diode of 5 µm apex width at different external bias conditions: (a) no bias (b) -0.8 V bias. Detected signal amplitudes are normalised to maximum at zero bias.

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