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Low-Noise Terahertz-Wave Detector: Fermi-Level Managed Barrier Diode

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The Fermi-level managed barrier (FMB) diode [1-4] is a new type of THz-wave detector that can simultaneously provide broad bandwidth and low noise-equivalent-power (NEP). Fig. 1 shows a band diagram of the FMB diode. The main feature of this device is that it uses a very low barrier height of about 100 meV, which is essential for obtaining low intrinsic differential resistance (i.e., low NEP) of the diode under a zero-biased condition. Such a small barrier height can be precisely controlled by the doping in the n-InGaAs anode layer on the basis of the phenomenon called band-filling effect. In addition, the use of a lattice-matched semiconductor hetero-barrier structure is advantageous in obtaining stable and reproducible device characteristics without being affected by the interface states. This feature results in good uniformity of the diode characteristics, which is especially important to construct an arrayed detector for imaging applications.

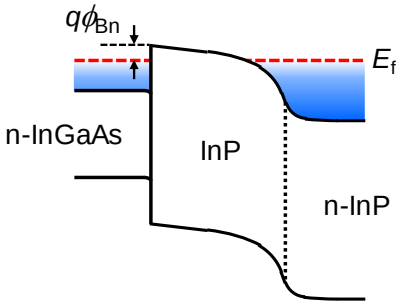

Fig. 1 Band diagram of FMB diode.

A quasi-optical FMB diode module integrating a pre-amplifier could be operated in a wide frequency range from 160 GHz to 1.4 THz with a typical voltage sensitivity of about 3 MV/W [2] and a very low NEPs of 3 pW/Hz$^{0.5}$ [2] both at 300 GHz in the direct detection mode. We also obtained fairly constant voltage sensitivity and NEP at 300 GHz with relative standard deviations of only about 9% for 23 modules [3]. An FMB diode can also be used for heterodyne detection. We proposed using the epi-layer transfer technique on SiC substrate for THz-wave detector [4]. This technique enables monolithic integration of a waveguide coupler with a detector diode. With this configuration, we obtained a very low NEP of 3×10^{-19} W/Hz at around 300 GHz with a local oscillator (LO) power of only about 70 μW [4]. This very low LO power necessary for obtaining a very low NEP is also an important advantage of FMB diodes since it can largely relax the power requirement for the LO signal source.

REFERENCES

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