Zero bias GaAsSb/InAlAs/InGaAs tunnel diodes for MMW-THz detection

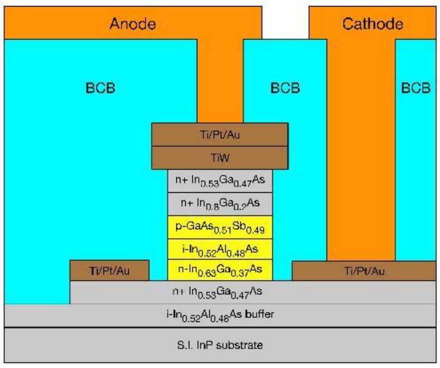
Mikhail Patrashin[*], Norihiko Sekine[*], Akifumi Kasamatsu[*], Issei Watanabe[*], Iwao Hosako[*], Tsuyoshi Takahashi[†], Masaru Sato[†], Yasuhiro Nakasha[†] and Naoki Hara[†]

[*]*Terahertz and Millimeter Waves ICT Laboratory*
National Institute of Information and Communications Technology, Tokyo 184-0015, Japan Email: mikhail@nict.go.jp
[†] *Fujitsu Laboratories Ltd., Atsugi 243-0197, Japan*
Email: takahashi.tsuyo@jp.fujitsu.com

Heterostructure tunnel diodes based on III-V compound semiconductors are the promising detector technology for MMW-THz systems. These devices demonstrate fast response, high cutoff frequencies due to small device capacitances, good sensitivity and feasibility of the monolithic integration with other semiconductor components and integrated circuits. This presentation describes on-wafer characterization of GaAsSb/InAlAs/InGaAs tunnel diodes for direct detection in 220-330GHz band.

Schematic structure of the device is shown in Fig.1. The non-linear characteristics of the detector result from the quantum-mechanical tunneling in the staggered band gap heterostructure of the device. Variable resistance of the diode produces the square-law rectification of the input signal power. Voltage sensitivity of more than 1000V/W was measured over 220-330GHz at room temperature (Fig.2). The inherent cutoff frequency of the 0.8 µm × 0.8 µm mesa diode was $f_C=(2\pi R_S C_J)^{-1}$ = 322 GHz.

The devices demonstrated enhanced temperature stability of the characteristics compared to the zero-bias Schottky barrier diodes. The estimated variations of the zero-bias sensitivity at temperatures from 17K to 300K were less than 2dB.



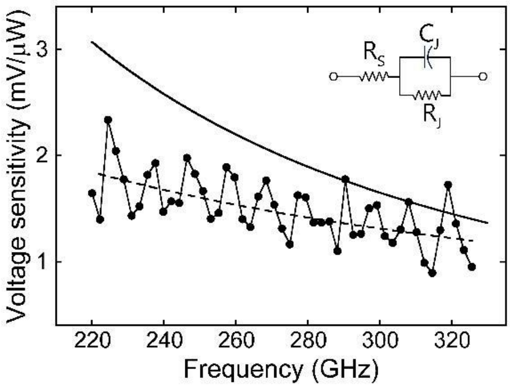


Fig. 1. Schematic cross-section of the completed tunnel diode detector after device processing (dimensions are not to scale).

Fig. 2. Measured voltage sensitivity of 0.8�m×0.8 �m mesa diode and the theoretical values $S_V= S_{C0}/R_S(2\pi f C_J)^2$ corresponding to the lossless impedance match at the detector's input (solid line). Insert shows the equivalent circuit model of the device consisted of the non-linear junction resistance R_J, the parallel junction capacitance C_J, and the series resistance R_S. S_{C0} is the low-level current sensitivity at zero bias. The parameters of the model were extracted from the measurements and were equal to S_{C0}= 11A/W, R_S= 130Ω and C_J= 3.8 fF.