Simplification in Device Structure and Fabrication Process of RTD THz oscillator

Tokyo Inst. of Technology, Mai Van Ta, Yusei Suzuki, Safumi Suzuki, and Masahiro Asada

E-mail: mai.v.aa@m.titech.ac.jp

Recently, THz waves, which have frequency from 100 GHz to 10 THz, attracted interest from many researchers owing to their promising applications. Resonant tunneling diode (RTD) oscillators are good candidate for THz light source because of room temperature operation, compactness and high oscillation frequency up to around 2 THz [1, 2]. However, the device structure and fabrication process of conventional RTD oscillator are relatively complicated. In this work we proposed and fabricated a novel RTD oscillator structure which has simple structure. Thanks to the simple structure, the step of fabrication process was dramatically reduced to less than half of conventional device process.

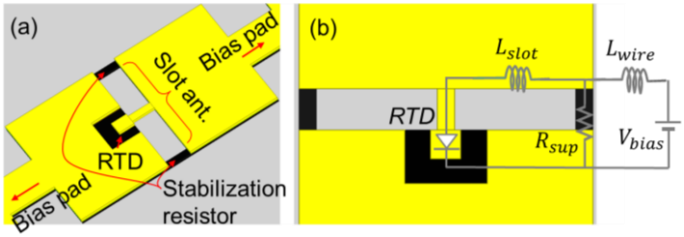

Fig. 1 (a) Novel oscillator structure, (b) equivalent circuit

The proposed structure is shown in Fig. 1(a). An AlAs/InGaAs double barrier RTD is integrated into slot antenna that also acts as a resonator and radiator. Stabilization resistors, which are utilized to suppress low-frequency parasitic oscillations, also form parts of the resonator. The equivalent circuit of the structure is shown in Fig. 1(b). In low frequency range, R_{sup} cancels negative differential conductance (NDC) of RTD, because L_{slot} is small and negligible. In THz range, the impedance of L_{wire} becomes large and separates DC bias circuit, the impedance of L_{slot} becomes larger than R_{sup}, and thus, the loss of R_{sup} becomes small and is canceled by the NDC for THz oscillation. The oscillation frequency is determined by LC resonance of RTD capacitance and L_{slot}. Unlike conventional RTD oscillators using MIM capacitors to separate the DC and RF circuits [1], proposed structure separates those circuits based on impedance difference of L_{slot} and L_{wire} in THz and low frequency ranges.

By eliminating MIM capacitor, fabrication process was dramatically simplified. Fabrication process of proposed structure is as follow. The electron beam exposure is carried out to obtain the electrode pattern. All electrodes are then formed using the same and only one evaporation process, followed by chemical wet-etching to form RTD mesa structure. Finally, device isolation and antenna formation are conducted using simple photolithography exposure for covering the RTD mesa and stabilization resistor area and chemical wet-etching. Using this simple fabrication process, we successfully fabricated single RTD oscillators with oscillation frequencies up to 235 GHz. The oscillation frequency was relatively low because the RTD capacitance became very large due to large RTD area. A higher frequency oscillation is possible with small RTD area.

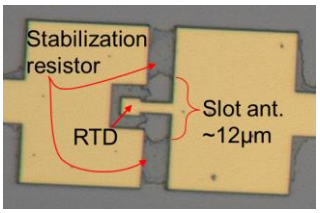

Fig. 2 Fabricated oscillator

[1] M. Asada, *et al.*, J. Infrared Milli. Terahz. Waves, **37,** 1185, 2016.
[2] R. Izumi, *et. al.*, AIP Advances, **9,** 085020, 2019.