Simulation of III-V Material Based Steep Slope Tunnel FET for RF Harvester Application

Saravana Selvan[1, 2,*], Goh Kooh Yik[2], Gobbi Ramasamy[1], Mukter Zaman[1]

[1]Faculty of Engineering, Multimedia University, Cyberjaya, Malaysia

[2]Faculty of Engineering & Computer Technology, AIMST University, Bedong, Malaysia

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Abstract

Due to the limitation of Sub-threshold Swing (SS) of 60 mV/dec in CMOS, alternately Tunnel FETs (TFETs) are more attractive in recent years since it has high energy efficiency and better switching performance even at a reduced voltage level. Because it has the benefits of Band to Band Tunneling (BTBT) behavior of operating mechanism and achieved a steep slope characteristic of less than 60 mV/dec. Despite these merits due to the band to band tunneling, the conventional Silicon based TFET is suffered from very low and limited ON-state current due to indirect and large energy gap feature. In the indirect band gap, the conservation of momentum occurs only when the absorption and emission of a photon are required which makes the absorption coefficient lower and limits the flow of electron. To address this problem, in this paper, a Hetero-Junction Tunnel FET (HTFET) devices employing with different lower bandgap materials (InAs/GaSb and InGaAs/InP) are designed by using Silvaco TCAD device simulator. The overall DC and analog/RF performance of HTFET devices are being extracted and investigated suitable for RF energy harvesting applications. The InAs/GaSb HTFET has shown a superior in characteristics by achieving a higher ON-state current of 2.3 mA/μm at V_{gs} = 1V, OFF current leakage of 4.18 x 10^{-11} A/μm, SS of 22.18 mV/dec and cut-off frequency range from MHz to GHz in operation. Under very low ambient RF level or sub-milliwatt (< 0 dBm) level conditions, the conventional CMOS based rectifier in RF harvester shows very poor performance and probably fails to convert RF signal into DC output voltage. This is due to the SS limitation of 60 mV/dec. Hence, HTFET based RF harvester is proposed and implemented in the circuit level by using the Keysight ADS software. The result indicates that a two-stage Dickson voltage multiplier design using InAs/GaSb HTFET can able to produce a DC output of 1.9 V, 1.6 μA @ 0 to -10 dBm, maximum efficiency of 59 % @ -14 dBm, operating frequency of 850 MHz at 10 kΩ loads with a sensitivity of 0 to -25 dBm.

Keywords: tunnel FET, band to band tunneling (BTBT), sub-threshold Swing (SS), RF harvester

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* Corresponding author. E-mail address: saravanan@aimst.edu.my

Tel.: +60103896500

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