High-Frequency Rectifying Characteristics of Si Nanowire Single-Electron Transistor

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1. Introduction

Rectifying operation beyond the conventional cutoff frequency of single-electron transistors (SETs) [1] is due to asymmetry in the tunneling rate with respect to drain voltage, which is responsible for asymmetry in the drain current, resulting in rectification [2]. Heavily doped Si nanowire-based SET is used for verifying it experimentally (Fig. 1).

2. Experimental Approach

A SET with designed wire length L of 52 nm and width W of 92 nm is selected for validation. After characterizing the device at the drain voltage of 10 mV, SET parameters (tunneling resistances and capacitances) were extracted from stability diagram (Fig. 2). Subsequently, rectifying behavior of the device was checked at various RF amplitudes, i.e. 18 mV and 1 MHz of constant frequency (Fig. 3). Finally, the frequency response of the device was analyzed for the range of 300 kHz - 3 GHz (Fig. 4).

3. Results and Discussion

It has been determined that the SET has the potential to rectify RF signals. However, flat frequency response is desired with a small drop at around 1 MHz. Use of ordinary needles instead of ground-signal-ground (GSG) probe for supplying high-frequency signal could be a reason for fluctuation towards the higher frequencies.

Reference: [1] Y. Takahashi, et al., ECS Transactions, 58 (9) 73-80 (2013).

[2] H. Inokawa, et al., IEEE Int. Conf. on EDSSC, 2018, Shenzhen, China.

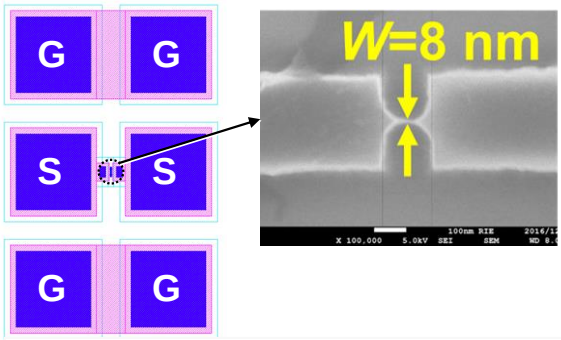

Fig. 1 Schematic diagram of the heavily doped Si nanowire SET.

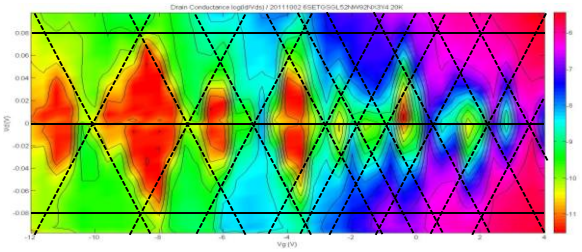

Fig. 2 Stability diagram of SET (L=52 nm, W=92 nm) at 20 K.

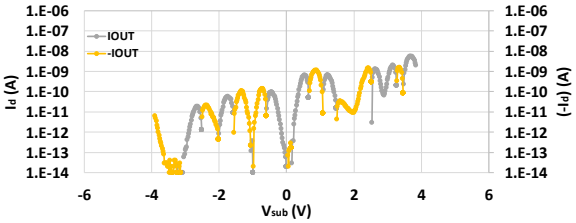

Fig. 3 Rectification through SET at 1MHz for 18-mV RF amplitude and 20 K.

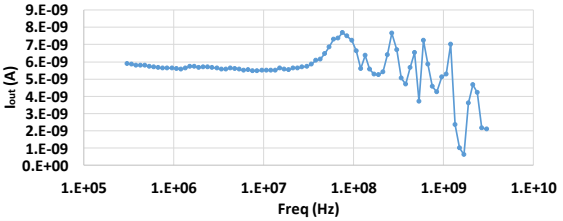

Fig. 4 Frequency response of SET at 20 K.