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Analysis of Photoresponse in SOI FinFET

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Introduction

It has been reported that the SOI MOSFET can operate as a single-photon detector, featuring dark counts several orders of magnitude smaller than that of conventional avalanche photodiode (APD), and low operation voltage less than a few volts [1,2]. In order to attain higher sensitivity to photogenerated carriers in the SOI body, further down scaling of the device is necessary. In this sense, SOI FinFET with multigate structure is very promising due to the superior short-channel behavior [3]. Here, we will present photoresponse characteristics of SOI FinFET for the first time.

Experiments

Figure 1 shows schematic diagram of n^+ poly-Si-TiN-gate n-channel SOI FinFET with intrinsic channel. In the measurement, the device is illuminated with continuous light, and the drain current waveform is analyzed.

Results and discussion

Figure 2 shows drain current waveforms for different levels of light intensity. We can see that "noise" amplitude increases as light intensity increases. Figure 3 compares the histograms of the drain current in the dark and under illumination of 206 μW/cm^2. The peak of the histogram swells to the right under illumination, indicating the presence of photogenerated and stored holes in the body of SOI. The histogram can be further decomposed into Gaussian peaks corresponding the discrete numbers of stored holes of 0, 1, 2, 3 and 4 from the left. The peak height may provide information on photogeneration and recombination dynamics [1]. However, peak separation in the histogram is not clear due to the insufficient signal-to-noise ratio and/or the hole lifetime shorter than the timing resolution of the measurement system.

Conclusions

Photoresponse of SOI FinFET was investigated, and evolution of the drain current waveforms with respect to light intensity was clearly observed. For the possible use as a single-photon detector, signal-to-noise ratio and response speed of the measurement system need to be improved.

References

[1] W. Du, et al. Opt. Lett. **36** (2011) 2800.
[2] W. Du, et al. Jpn. J. Appl. Phys. **51** (2012) 06FE01.
[3] T. Hayashida, et al. IEEE Trans. Elec. Dev. **59** (2012) 647.

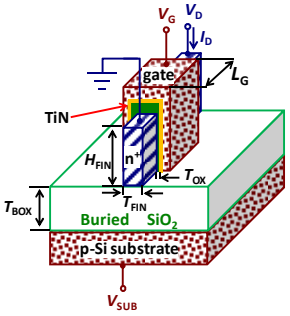

Fig.1 Schematic diagram of the SOI FinFET. T_{BOX}, T_{FIN}, H_{FIN}, L_G and T_{OX} are 150, 50, 40, 50 and 2.5 nm, respectively.

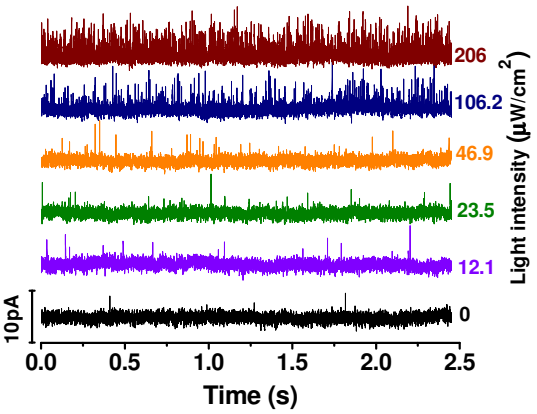

Fig. 2 I_D waveforms at 300 K for various light intensities (λ=550 nm). Base line current is about 1 nA, and each waveform is shifted for clarity. V_D, V_G and V_{SUB}, are 0.05, 0.164 and 0 V, respectively.

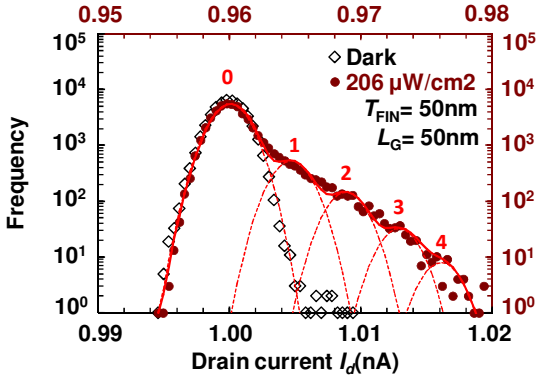

Fig. 3 Histograms of digitized I_D from the waveforms in Fig. 2. Data acquisition time step is 50 μs, and 50,000 I_D values are classified into bins with a width of 0.2 pA. Decomposed peaks correspond to different numbers of stored holes.