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Interband Tunneling in Si Lateral Nano-*pn* Junctions

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Introduction

Recently, nanometer-scale *pn* junctions have been extensively studied.[1-6] In particular, tunneling in nano-*pn* junctions is important for future nanoelectronics. For the conventional heavily-doped (degenerated) *pn* diodes, it is known that interband tunneling occurs, which is the basis of Esaki tunneling diodes.[7] The tunneling in forward-bias mode can be seen as negative differential conductance (NDC) in current-voltage (*I-V*) curve. In this work, we fabricated heavily doped nanoscale Si lateral *pn* junctions and studied *I-V* characteristics in forward-bias mode. As a result, we found similar NDC behavior at low temperatures even for the nanowire-*pn* junctions.

Device structure

We fabricated lateral nanowire silicon-on-insulator (SOI) *pn* junctions, with structure schematically shown in Fig. 1. Nanowires were patterned on the SOI layer by an electron beam (EB) lithography technique. Then, a selective doping technique was used to create the *n*-type (phosphorus-doped) and *p*-type (boron-doped) regions. A 10-nm-thick thermally grown SiO_2 layer was used as a mask for phosphorus doping process, while for boron doping mask, we used a 15-nm-thick ECR-deposited Si_3N_4 layer. After final process, doping concentration was estimated on the order of 5.0×10^{19} cm^{-3}. The nanowire thickness and length are about 15 nm and 1000 nm, respectively, while the nanowire width is varied as parameters. The *p*-type region is connected to a voltage source, while *n*-type region and substrate are grounded.

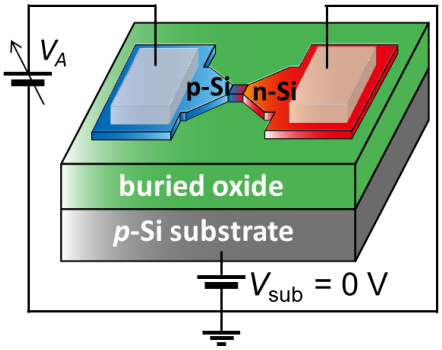

Fig. 1. Schematic structure of nanoscale lateral *pn* junctions and *I-V* measurement setup.

I-V characteristics

We measured current versus applied bias (*I-V*) characteristics at room (T = 300 K) and low temperature (T = 10 K) in dark condition. Preliminary results are shown in Fig. 2. It was found that, at low temperature, *I-V* characteristics exhibit NDC. This behavior is similar to the conventional Esaki diode characteristics, suggesting that the observed features are most likely a signature of interband tunneling. However, more investigation is necessary to be done before fully clarifying this event.

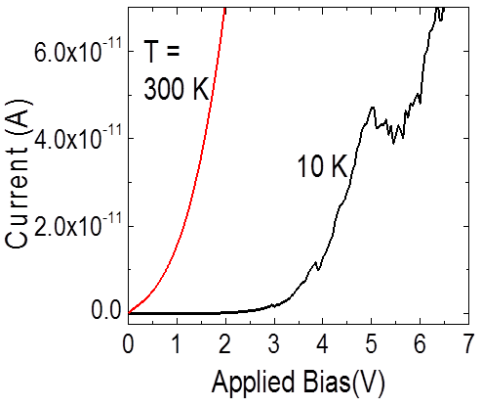

Fig. 2. *I-V* characteristics in forward bias at different temperature (*T* = 300 K and *T* = 10 K). For *T* = 10 K, NDC can be observed.

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