Light-induced Electrical Switching of Porphyrin-Covered Silicon Nanowire FETs

Eunhye Baek[1], Sebastian Pregl[1,2], Lotta Römhildt[1],
Larysa Baraban[1] and Gianaurelio Cuniberti[1,2]

[1]Institute for Materials Science and Max Bergmann Center of Biomaterials, Technische Universität Dresden, Budapester str. 27, 01069 Dresden, Germany
[2]Center for Advancing Electronics Dresden, Technische Universität Dresden, 01062 Dresden, Germany

eunhye.baek@nano.tu-dresden.de

Abstract

The development and commercialization of novel hybrid intelligent systems with rich functionalities, providing strong benefit in the area of health-care, and electronic applications are among the most crucial topics of the scientific community and industrial players. Nanowires can provide excellent building blocks for hybrid nanoelectronics, due to their efficient charge transport characteristics and good compatibility with molecules [1-3].

Here we present light-induced switching characteristics of porphyrin-coated silicon nanowire field effect transistors (Si NW FETs) and demonstrate their capabilities for design of hybrid nanodevices – consisting of organic complexes and inorganic nanowires.

Porphyrin is the organic pigment molecule, absorbing broad range of visible light and release electrons that move easily through molecular bonding [4]. Bottom-up fabricated Si NW based FETs, (see Figure 1) containing nanosized Schottky barriers (SB) [5], are functionalized by porphyrin molecules.

Here we show the optoelectrical current-switching depending on porphyrin concentration. Switching current near threshold region of transfer curves, is investigated on time domain (Figure 2). Switching time constant is extracted using exponential growing and decaying function. Also, on/off ratio is characterized according to the concentration change of porphyrin. As the concentration increases, the devices show fast switching due to low resistance of porphyrin. On/off ratio is reduced when the Porphyrin layer is too thick to conduct the light irradiation. Switching of Si NW FETs highly reflects the electrical change of porphyrin molecules by light. To demonstrate significant factors of concentration-dependent switching of porphyrin-covered devices, electrical charging mechanism through molecules and nanowires has been understood, that allows the systematic integration of the molecular hybrid devices.

References

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Figures

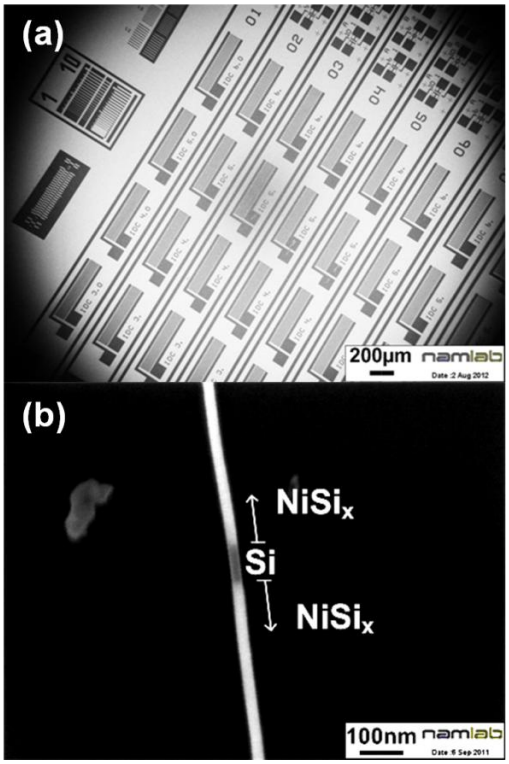

Figure 1. SEM images of (a) patterning and metal contacts of devices and (b) formation of nickel-silicide in NW to act as Schottky barriers.

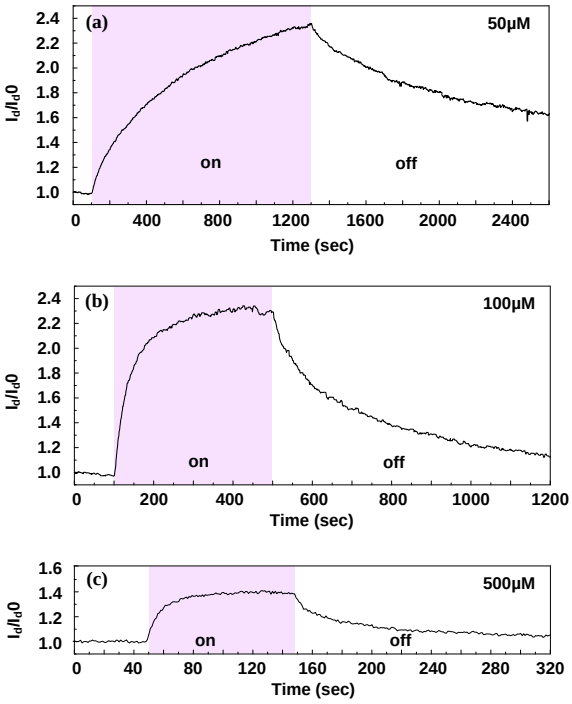

Figure 2. Switching behavior of silicon nanowires based device upon light illumination. Ratio of I_d and I_d0 of one complete switching period of (a) 50µM, (b) 100µM, and (c) 500µM of porphyrin-covered device.