Junctionless Nanowire Transistors: Promising Devices for Biosensor Applications

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Junctionless nanowire transistors (JNTs) are gated resistors where the source, channel and drain have the same type of doping without any dopant concentration gradient. The JNT is the simplest transistor structure possible and probably the most scalable of all field effect transistor (FET) structures. It is easier to fabricate than standard metal-oxide-semiconductor FETs (MOSFETs) and has also a number of performance advantages over them.[1,2,3] Two of the advantages are especially important for the JNT application as sensors:

1. The current flow in JNTs is not controlled by a reverse biased p-n junction as in standard MOSFETs but entirely by the gate potential. Therefore, they are more sensitive to any change in the electrostatic potential on the channel surface acting as a gate potential.

2. JNTs demonstrate bulk conductance near the centre of the channel, in contrast to the conductance in a thin surface inversion or accumulation layer near the gate in the inversion mode or accumulation mode MOSFETs, which leads to higher drive currents. Moreover, this fact makes the conduction in JNTs less affected by the noise-inducing parasitic surface states than in the case of conventional MOSFETs, which is very important for achieving high signal-to-noise ratio and low detection limit.

In the presentation, these advantages will be discussed in detail followed by results of implementation of silicon (Si) JNTs as chemical and biological sensors. A series of experiments for sensing the ionic strength and the pH value of buffer solutions have proven the excellent sensitivity of these sensors.[4,5] Moreover, sensing of the protein streptavidin at a concentration as low as 580 zM has been observed, which is by far the lowest concentration of this protein ever detected and corresponds to detection in the range of only few molecules.

The high sensitivity of JNT sensors, combined with their very simple structure and relaxed fabrication process, makes them promising candidates for cheap mass production by the conventional microelectronic technology. This can enable their numerous applications in various fields where fast, low-cost, label-free, low-volume and real-time detection of chemical and biological species at low detection levels is required.

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