Nano-bridge FET Array for DNA hybridization Detection

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Electrical biosensors provide real time and label free detection. Conductance biosensors are a class of electrical biosensors that show promise for point-of-care and disease discovery due to real time, low cost, ease of miniaturization and label-free operation. However, it is critically important for electrical biosensors to have enough high sensitivity for low-concentration detection of bio-species, which is still missing today. We have introduced Nano-bridge biosensor as an improved structure with leads to higher Signal to Noise Ratio. In compare with other planar electrical biosensors that have one DNA exposed surface, nano-bridge sensor has two surfaces, which DNA can bind to them (top and bottom), as it is shown in Figure 1.

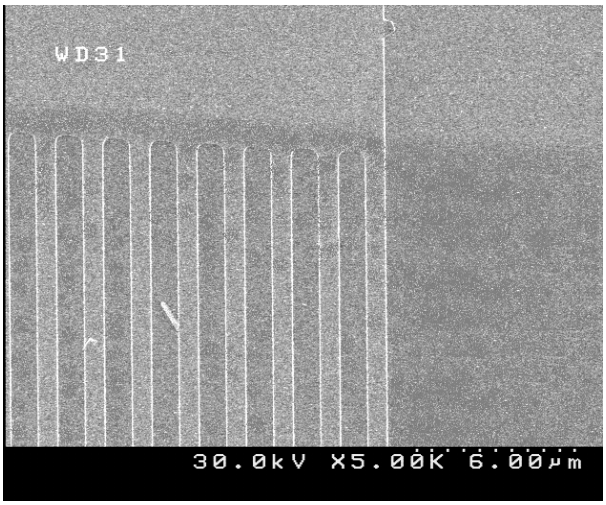
The nano-bridges are fabricated on SOI wafers with SOI thickness of 1 um wafer-buried-oxide (BOX); the final size of the nanobridges is 300nm width with 60nm of thickness, and 50um length (Figure 1 and 2). These nanobridge biosensors are acting as fully depleted SOI double gate transistors, which have higher I-Vg, slop than the conventional transistor. It means that the current change (dI) due to DNA binding (dVg) is more than this change in conventional planar biosensors. To operate similar to a double gate SOI transistor, DNA or charged bio-molecule in solution should be able to flow around the nano-bridges. For this purpose, there is a channel fabricated under the bridges through wet etching of the BOX layer that makes the sensor suspended. In the top there is micro-fluidic channel made in PDMS (rubber silicon) with 30um height with the same width (30um) as the channel underneath nanobridges in silicon (Figure 2). These two micro-fluidic channels, one in SOI wafer, one in PDMS layer are getting aligned and bonded through thermal bonding in 90^C.

In figure 3 the modeling results of nano-bridge device with two-sided DNA immobilization is compared with the conventional planar (transistor) biosensor and single-sided SOI device. The simulation was done in MEDICI. The result shows that in nano-bridge sensor, the ratio of current modulation due to the target DNA hybridization to the current modulation due to probe DNA binding (loading or functionalization) is 7 times higher than this ratio in conventional planar biosensor. This shows the improvement of Signal to Noise ratio in the nanobridge biosensors.

Figure 4a shows the experimental results of DNA charge detection; the sensor is made of p-type silicon; PLL (Ploy-L-Lysine) functionalized surface is increasing the conductance of Nano-bridge due to the positive charge of PLL layer. This makes the bridge device in inverted mode. Binding the DNA probe molecule to the sensor cause a drop in conductance due to the DNA's negative charge and the similar event happens in complimentary DNA strand hybridization. Figure 4b shows the current modulation in complimentary versus non-complimentary binding, in 7 experiments. Due to nonspecific binding, there are always some current modulation which shown in the first bar.

References:

1) Parizi, K.B. Nishi, Y., 2008 IEEE International SOI Conference, Page(s): 87 - 88
2) Parizi, K.B.; Melosh, N.; Nishi, Y.; 2009 IEEE International SOI Conference.



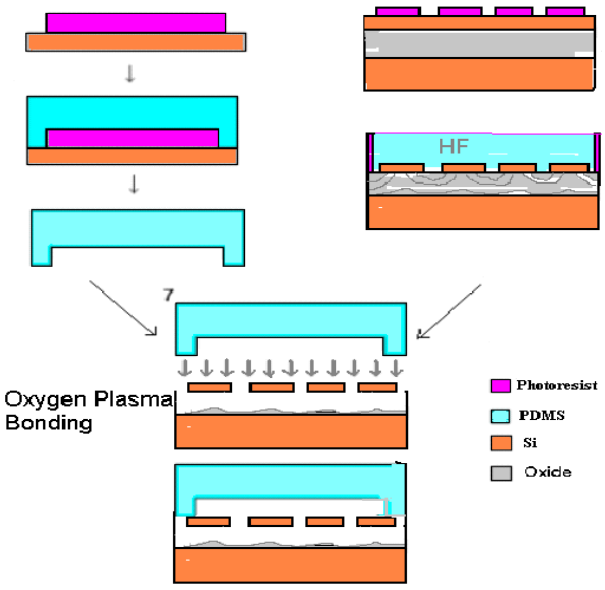


Fig. 1. SEM Micrograph of Nanobridge Biosensor Fig. 2. Fabrication Process

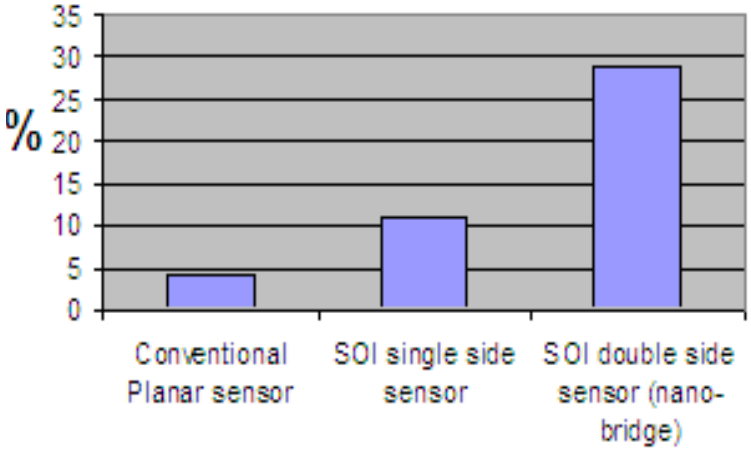
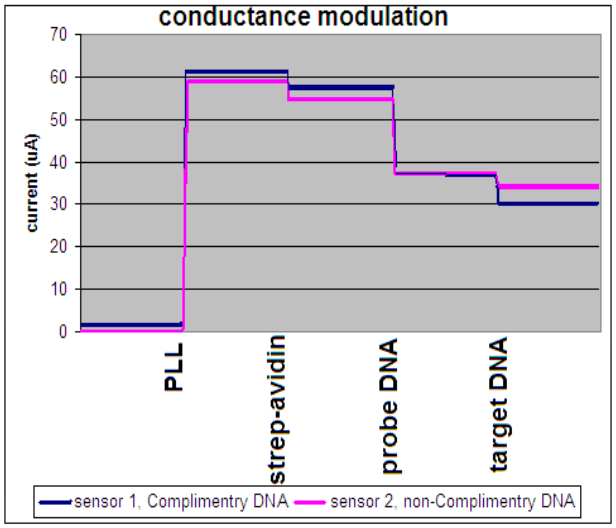
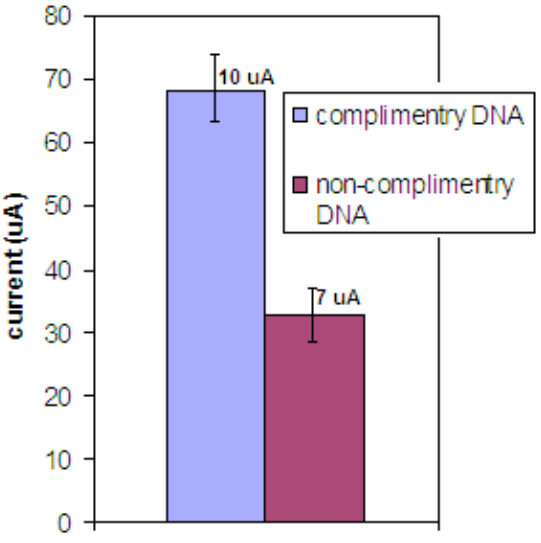


Fig. 3. Ratio of conductance change in DNA hybridization to DNA functionalization



a)



b)

Fig. 4. a) current modulation in different injection stages in DNA experiment b) complimentary vs. non-complimentary DNA measurements