DNA Concentrating by Electro-Kinetic Forces in 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 which 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. the final size of the nanobridges is 300nm width with 60nm of thickness, and 30um length (Figure 1c). These nanobridge biosensors are acting as fully depleted SOI double gate transistors, which have higher I-Vg, slope 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 in solution should be able to flow around the nano-bridges. For this purpose, there is a channel fabricated under the bridges.
In highly dilute DNA solution, it takes longer time for DNAs to bind to the surface of sensor. By electro-kinetic forces in microfluidic channel, DNAs can be concentrated near the sensor and the chance of being captured by sensor increases.
By applying an AC signal to the electrodes at both sides of sensor while sensor is grounded, electro-osmosis forces generate a solution bulk flow that circulates the DNAs near the sensor. Adding a DC voltage to the AC applied one, creates electro-phoresis forces that pushes and keeps the negatively charged DNA molecules close to the sensor. It increases the effective concentration of DNA near the nano-bridge while the solution in the other regions of the microfluidic channel is still diluted.
Figure [2] shows two florescent photograph of sensor while the DNA molecules in solution are labeled with a florescent. Figure [2b] is the sensor after 4minutes applying of AC and DC biases for generating electrokinetic forces. As can be seen, Figure [2b] is brighter than figure [2a] because there is more DNA molecules concentrated near sensor due to these forces.
Figure [3] shows the experimental results of DNA detection in both cases of with/without electro-kinetic forces. The detection signal for a specific sample concentration increases by applying these forces. It shows that the concentration of DNA molecules near the sensor is increased due to the help of electro-kinetic forces.

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.

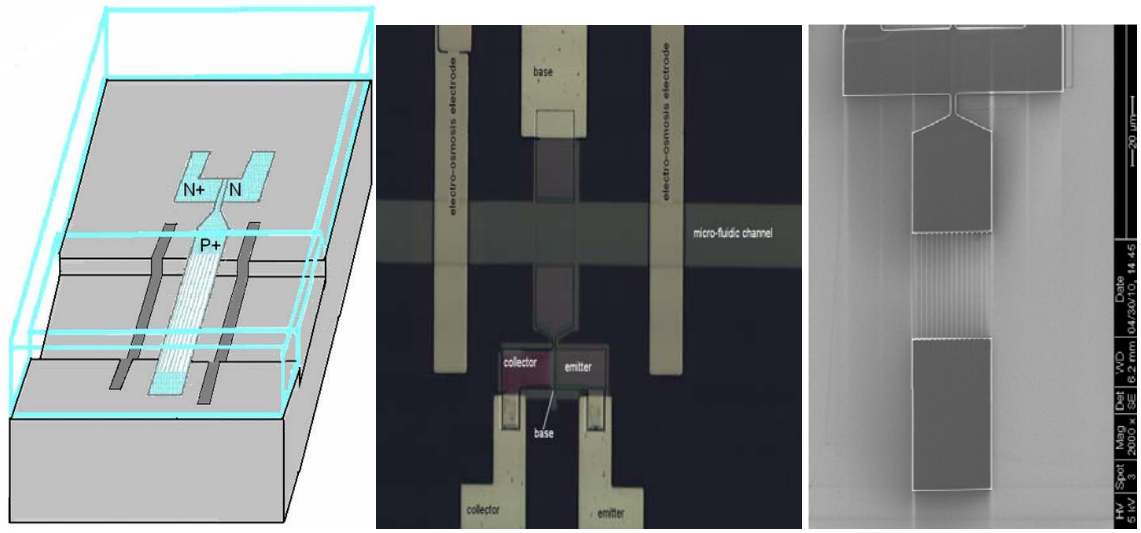

Figure [1]: a) Schematic view, b) optical and c) SEM Micrograph of Nanobridge Biosensor.

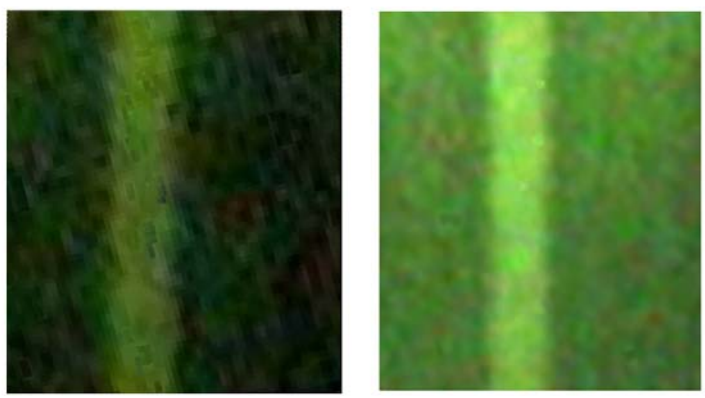

Figure [2]: florescent image of sensor in a fluorescently DNA labeled solution,
a) no electro kinetic forces have been applied, b) with electrokinetic forces

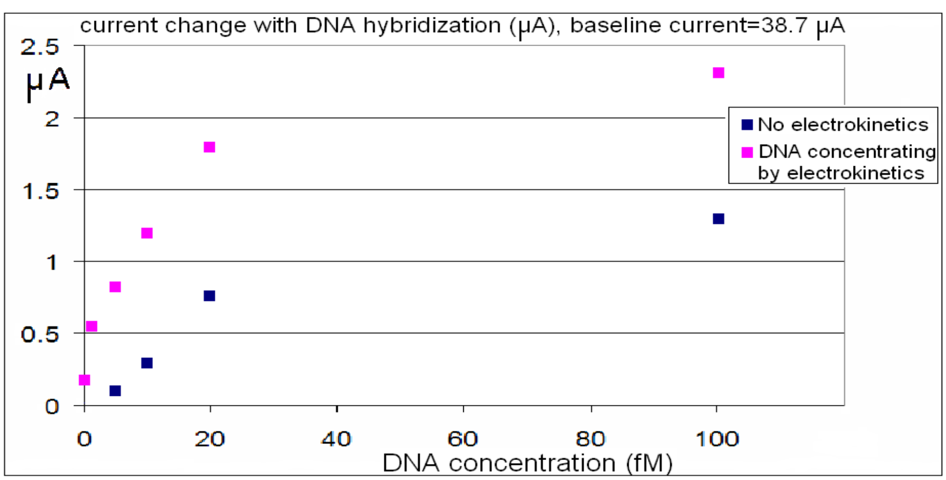

Figure [3]: experimental results of DNA detection, show that the detection signal with help of elctrokinetic forces is larger than without using them.