Polymer Nanowire Based Impedance Biosensor

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Abstract

In this paper, we have proposed an impedance biosensor based on polymer nanowire (made of polyaniline) for efficient electric field mediated capture of biomolecules. Existing polymer nanowire based biosensors fail to achieve high sensitivity for low surface to volume ratio as the whole length of the nanowire is exposed to the analyte .Also biosensors are dependent on diffusion mediated capture of biomolecules.Results for low concentration the percentage volume coverage by biomolecules is less. In the proposed structure, the problem of low sensitivity has been overcome by proper design of electrodes which enable electric field mediated capture over a small volume of the nanowire so that the percentage volume occupied by biomolecules is larger than the conventional cases. The design of electrodes structure to be fabricated were first simulated using the COMSOL Multiphysics conductive media physics interface.
After the design of electrodes structures was completed, we observed the nature of streamline current flow distribution and electric field through the devices. The process steps are given below-
a)First we design two electrodes(20µm*20µm*1µm) which are separated by a distance of 980µm.
b)A polyaniline nanowire is deposited on the middle portion of one of the electrodes.
c)We use three water columns(500µm*500µm*µm) of which two water columns are placed on the two electrodes and the third water column is placed between the two water columns.
d)Now we set the boundary conditions as follows-
Selected material conductivity
Electrodes aluminium 35.5e^6 s/m
Nanowire Polyaniline 0.00027 s/m
Liquid column water 0.0000027s/m
e) After putting the boundary conditions we put sub boundary conditions on the structure to 'continuity' in the internal portions and 'electric insulation' in the boundary side.
f)Next step is to mesh the structure.
g)Now we process the structure to find the total current density and electric field.
For simulation of the structure, a potential difference was applied between the two electrodes. Figure 2 shows the streamline current flow distribution between the two electrodes through the water column. It is observed that the electric field in every point of the water column on the structure is high enough to detect biomolecules very efficiently. Parts adjacent to the electrodes have the maximum current density and electric field which decreases gradually when we move away from the electrodes. A 3D multiphysics modelling of polymer nanowire based biosensor was done to investigate streamline current flow distribution and electric field in every point of the water column.As a result,this device shows very high sensitivity by proper design of electrodes which enable electric field mediated capture over a small volume of the nanowire so that the percentage

volume occupied by biomolecules is larger than the conventional cases.With proper design of electrodes the electric field lines are distributed uniformly through the entire liquid column so that even very few bio molecules get attracted towards the nanowire. Hence this device can be used to detect biomolecules very efficiently.

Figures used in the abstract

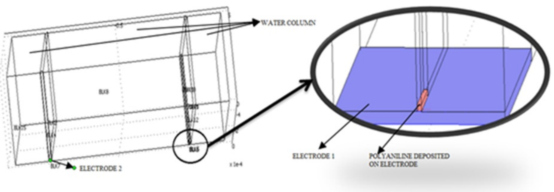

Figure 1: Cross sectional view of the structure in COMSOL Multiphysics.

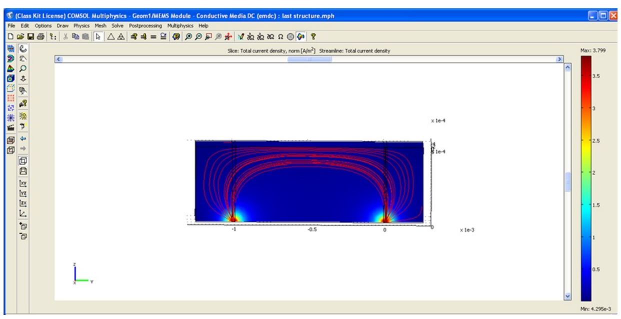

Figure 2: Streamline current flow distribution between the two electrodes through the water column.