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DNA sequencing using Nanomanufacturing

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ABSTRACT

In this paper, we nanomanufacture for the first time a novel DNA sequencing using nanoscale hole, in synthetic single digit nanometer thickness membrane. The DNA sequencing is carried out for each base of DNA to sequence and detect by placing a multimeter and the readings are taken on the edges of the synthetic single digit nanometer thickness membrane. The multimeter readings gives the voltage change readings for each base of DNA as there will be a change in concentration in the presence of DNA inside a nanoscale hole, in synthetic single digit nanometer thickness membrane.

Keywords— *Nanomanufacturing, DNA Sequencing*

1. INTRODUCTION

The advent of technology for fabricating devices of the order of a few nanometers have paved way for single molecule sensing [1-12], water desalination[11], nanopump [12], protein translocation [11] and nanopower generators [1]. In this paper, we nanomanufacture for the first time a novel DNA sequencing to detect and sequence for each base of DNA using nanoscale hole, in synthetic single digit nanometer thickness membrane.

2. DESIGN AND NANOMANUFACTURING

Nanomanufacturing of nanoscale hole, in single digit nanometer thickness membrane of ~ 12 nm (six atomic layers) of synthetic single digit nanometer thickness membrane is fabricated using Focused Ion Beam (FIB) method. SEM image of the synthetic nanomanufacture nanoscale hole, in single digit synthetic nanometer thickness membrane taken from Centre for NEMS and Nanophotonics, CNNP, SEM facility at IITM, Chennai, India is shown in Fig. 1.

3. MATHEMATICAL MODELING

Poisson Nernst Planck + Navier Stokes equations (PNP+NS) for ions, fluids, DNA, electrolyte solution, for a synthetic SiO_2 single digit nanometer thickness membrane, with nanoscale hole of diameter 5 nm, with ss_poly(dA)40 DNA taken from APBS [13] and the APBS DNA file is converted into .stl file. The .stl file matches the structure with the NAMD, VMD visualization of the same DNA [14]. The .stl file is meshed with open access snappyHyperMesh C++ package open source software. The snappyHyperMeshed .stl file is loaded into the PNP+NS equations using open access paraview C++ package open source software. The synthetic SiO_2 single digit nanometer thickness membrane, with nanoscale hole and the snappyHyperMeshed .stl file is mapped into one open access OpenFOAM C++ package open source software. The synthetic SiO_2 single digit nanometer thickness membrane, with nanoscale hole and the snappyHyperMeshed .stl file, is together hexogonal meshed using our written blockMeshDict C++ package compatible with open access OpenFOAM C++ package open source software. PNP+NS equations for ions, fluids, DNA, electrolyte solution, for a synthetic SiO_2 single digit nanometer thickness membrane, with nanoscale hole is written mapping APBS [13], open access snappyHyperMesh C++ package open source software, open access paraview C++ package open source software, open access OpenFOAM C++ package open source software and blockMeshDict C++ package compatible with open access OpenFOAM C++ package open source software.

4. SIMULATION DETAILS

The simulated domain consists of nanoscale hole of diameter = 5 nm and synthetic single digit nanometer thickness membrane of thickness = 16 nm. KCl buffer solution concentration 50 mM is used. The charge on the walls of the nanopore is σ = -41.8 mC/m^2

atypical for SiO_2 membrane. The charge on the DNA is charge $\sigma = 0$ mC/m^2 as DNA is non defective molecule and healthy DNA is a non broken and fully bonded with no net charge molecule.

5. RESULTS AND DISCUSSION

The change in concentration in the presence of DNA (see Fig. 2) is measured using a multimeter as there will be an induced voltage change on the synthetic single digit nanometer thickness membrane (see Fig. 3). Place the multimeter and the readings are taken on the edges of the synthetic single digit nanometer thickness membrane. The induced voltage is ~20 mV.

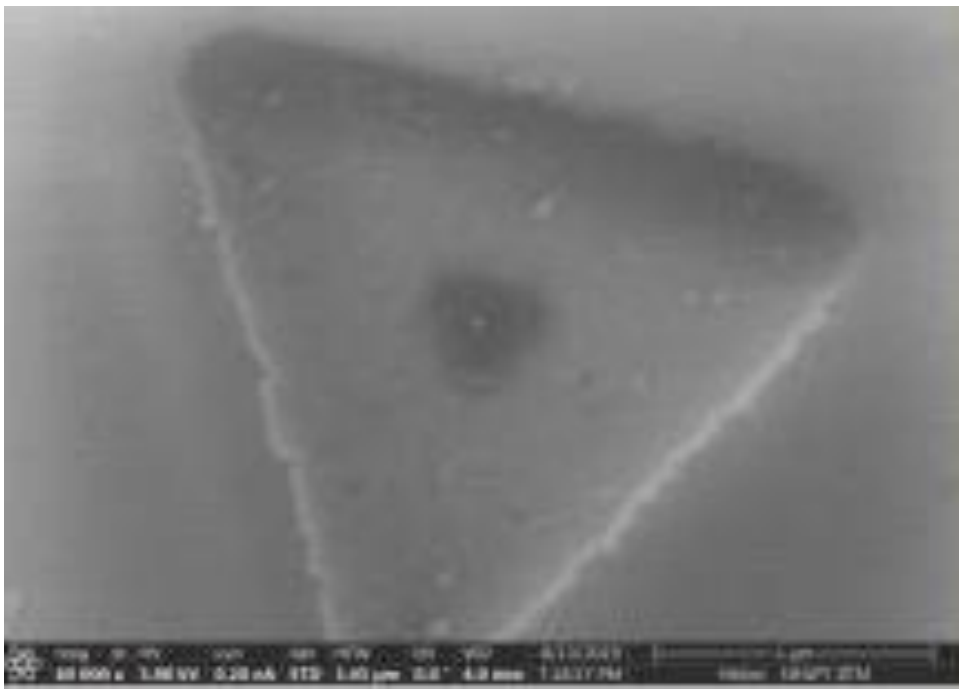

Figure 1. Nanomanufacturing of nanoscale hole, in synthetic single digit nanometer thickness membrane. SEM image of CFD laboratory, IIT Madras, Chennai, India, nanomanufacture nanoscale hole, in single digit nanometer thickness membrane taken from Centre for NEMS and Nanophotonics, CNNP, SEM facility at IITM, Chennai, India.

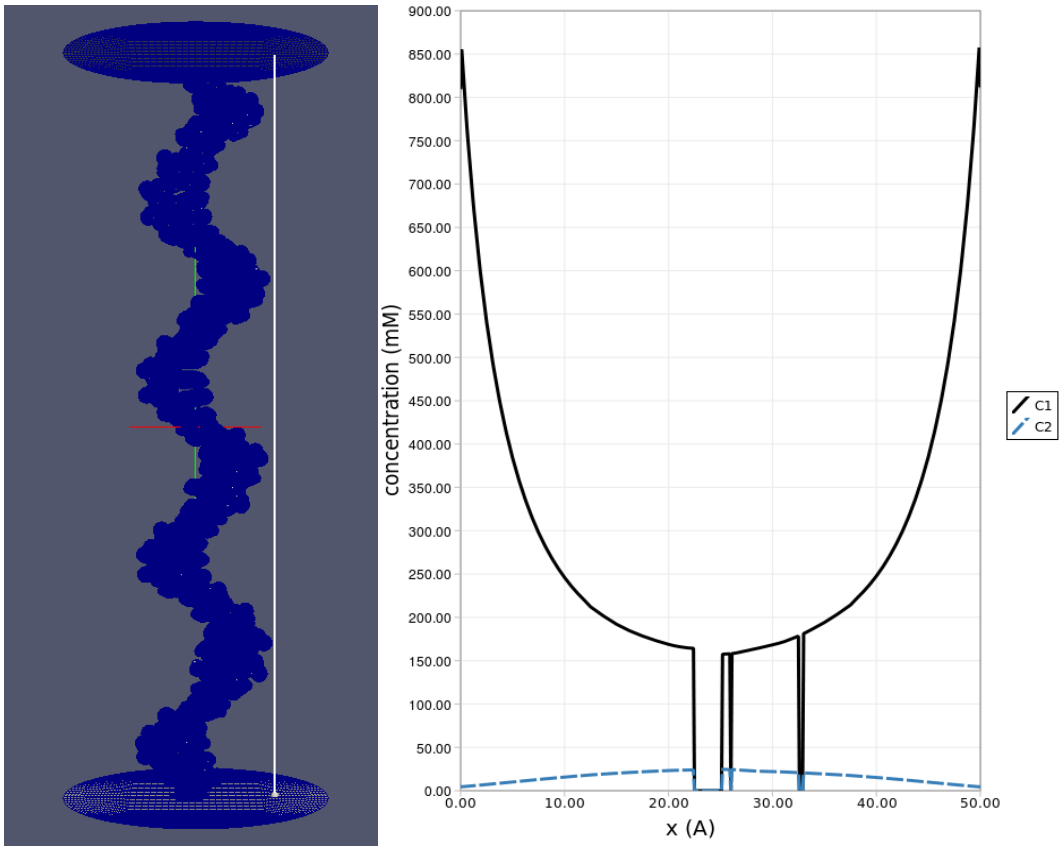

Figure 2. Numerical simulation of K^+ (C1) and Cl^- (C2) concentration distribution at z = 70.5 angstrom across the synthetic SiO_2 nanomanufacture hole and synthetic single digit nanometer thickness membrane.

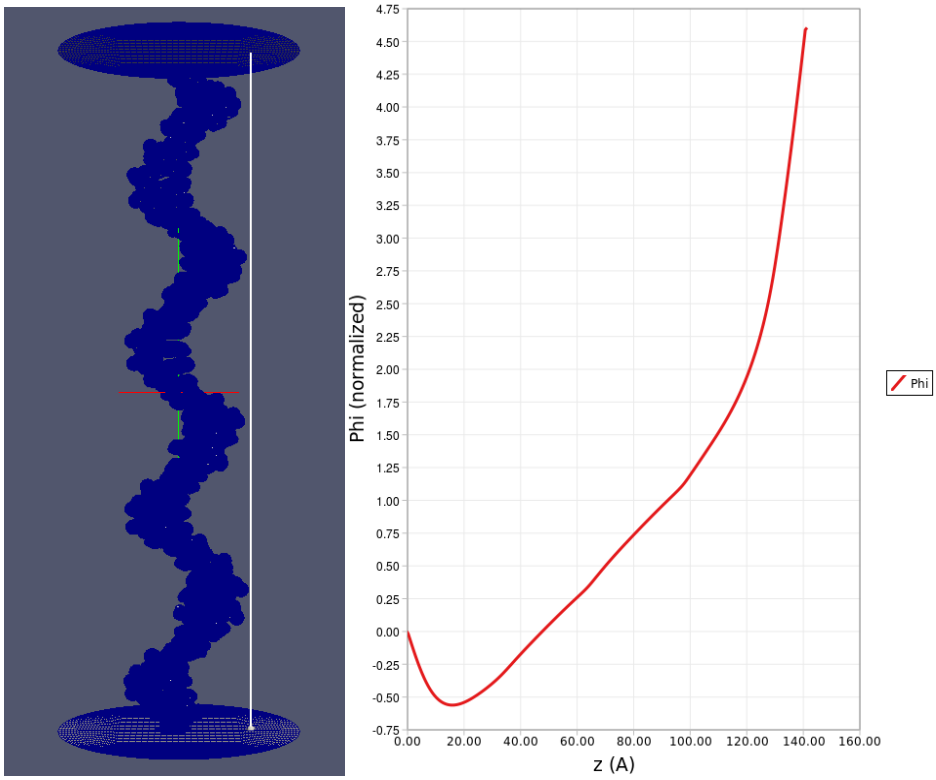

Figure 3. Numerical simulation of voltage variation along the axial direction away from the ss_poly(dA)40. Phi (normalized) = Voltage*F/RT, where F is Faraday's constant, R is gas constant, T is temperature = 300 K.

6. CONCLUSIONS

Here, a novel DNA sequencing is nanomanufactured for the first time using nanoscale hole, in single digit nanometer thickness membrane. The DNA sequencing is carried out for each base of DNA to sequence and detect by placing a multimeter and the readings are taken on the edges of the single digit nanometer thickness membrane. The multimeter readings gives the voltage change readings for each base of DNA as there will be a change in concentration in the presence of DNA inside a nanoscale hole, in single digit nanometer thickness membrane.

7. ACKNOWLEDGEMENTS

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