Computer Modeling and Design of Carbon Nanotube Embedded MOS Chemicapacitive Sensors

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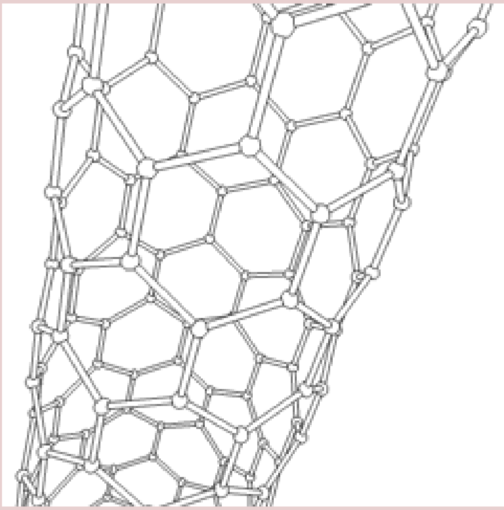
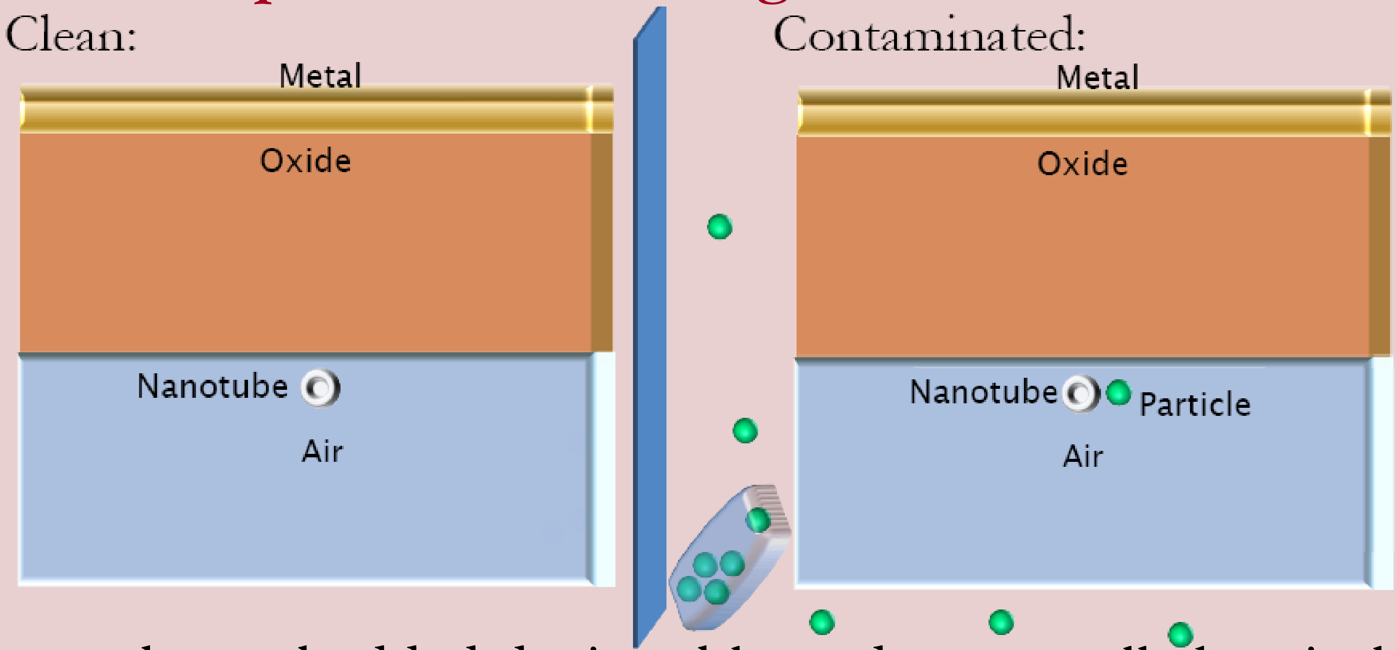
Carbon Nanotube:



Schwarzm. (30 August 2004). Carbon nanotube. *August 1 2006,* Available: http://commons.wikimedia.org/wiki/Image:Kohlenstoffnanoroehre_Animation.gif. Used under GNU FDL

Our Proposed Sensor Design:



- We aim to simulate a nanotube-embedded device able to detect small chemical and biochemical particles with a high sensitivity and quick response rate.
- Such a device will help to mitigate the risk of environmental contamination harming soldiers, an unfortunate tactic that has been a feature of warfare for thousands of years.

Numerical Modeling and Results

- To study the electrostatic properties of the sensor, we solve the **Poisson Equation** for ϕ : $\nabla \cdot (\varepsilon \nabla \phi) = -q\rho$ where

  ϕ is the electrostatic potential; ε is the dielectric constant;
  ρ is the net charge density; q is the electronic charge

- Interface equation (all nonuniform meshes):

$$\frac{\varepsilon_{oxide}}{\Delta_y(j-1)}\phi\left(y_0-\Delta_y(j)\right)-\left(\frac{\varepsilon_{oxide}}{\Delta_y(j-1)}+\frac{\varepsilon_{air}}{\Delta_y(j)}\right)\phi(y_0)+\frac{\varepsilon_{air}}{\Delta_y(j)}\phi\left(y_0+\Delta_y(j)\right)=0$$

- Two dimensional nonuniform mesh numerical approximation equation:

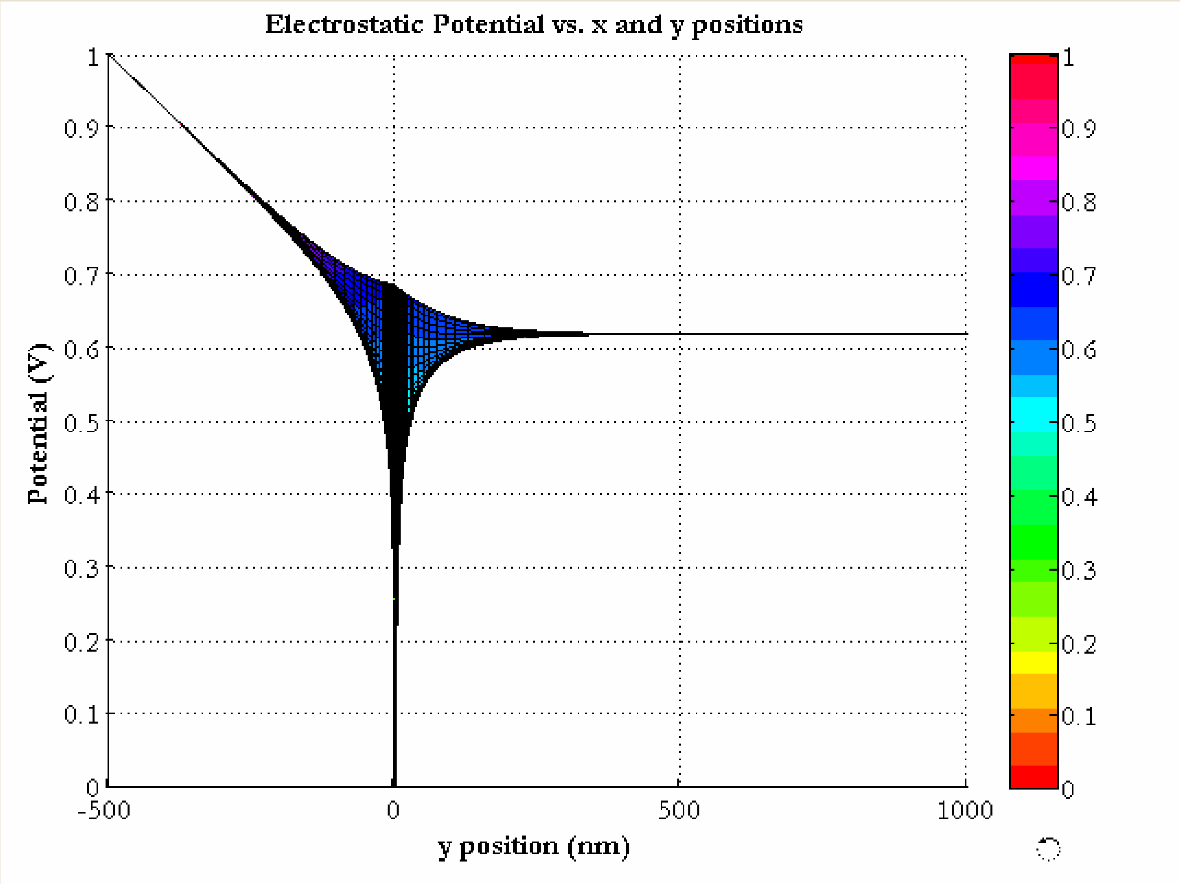
$$\frac{2}{\Delta_y(j-1)\left(\Delta_y(j)+\Delta_y(j-1)\right)}\phi\begin{pmatrix}x\\ y-\Delta_y(j)\end{pmatrix}+\frac{2}{\Delta_x(i-1)\left(\Delta_x(i)+\Delta_x(i-1)\right)}\phi\begin{pmatrix}x-\Delta_x(i)\\ y\end{pmatrix}$$

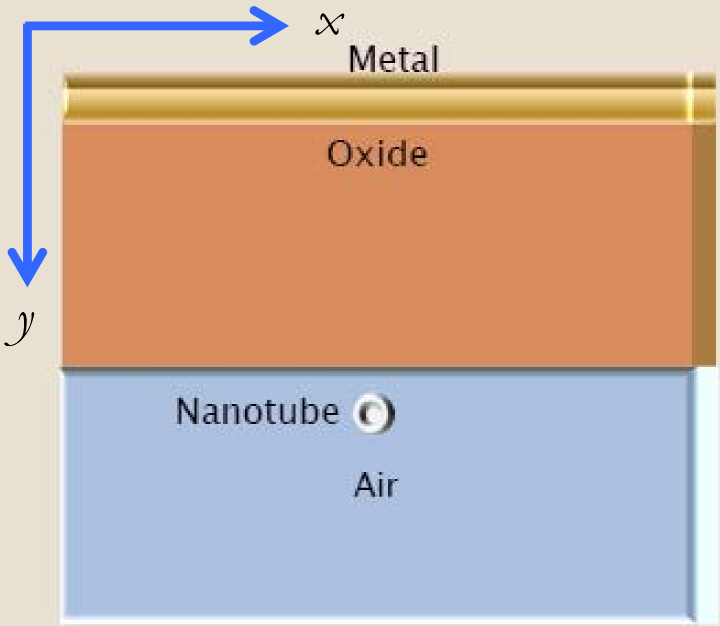
$$-\left(\frac{2}{\Delta_x(i-1)\Delta_x(i)}+\frac{2}{\Delta_y(j-1)\Delta_y(j)}\right)\phi\begin{pmatrix}x\\ y\end{pmatrix}$$

$$+\frac{2}{\Delta_x(i)\left(\Delta_x(i)+\Delta_x(i-1)\right)}\phi\begin{pmatrix}x+\Delta_x(i)\\ y\end{pmatrix}+\frac{2}{\Delta_y(j)\left(\Delta_y(j)+\Delta_y(j-1)\right)}\phi\begin{pmatrix}x\\ y+\Delta_y(j)\end{pmatrix}=0$$

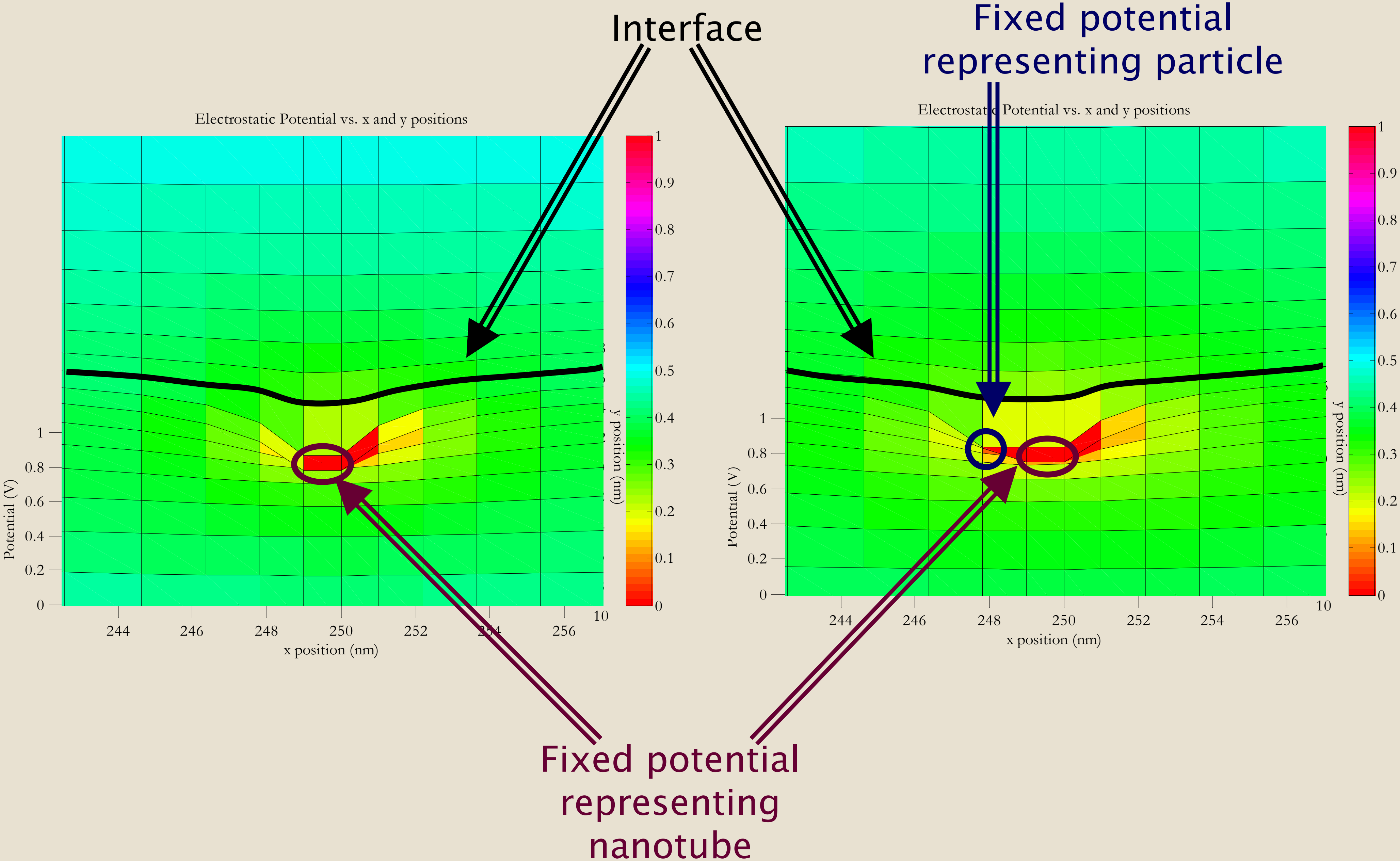
Solution for Potential

- **Overview of potential with 2 nm by 2 nm nanotube embedded in MOS:**





Zoom In on Potential



Analysis and Conclusions

- **The numerical solutions show unequivocally that the proposed design for a nanotube sensor is advantageous over the traditional design in terms of sensitivity upon the insertion of a particle.**