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# Finite Element Technique for Electrochemical Copper Deposition


***Michael Gyamerah, Joseph Lavan,***
***Irvin Osborne-Lee, and Sarhan M. Musa***


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***Prairie View A&M University***
***Texas, U.S.A***

# Outline of the presentation

- Introduction
- Previous attempt at the Problem
- Aim
- Modeling of Electrochemical Copper Deposition using FEM with COMSOL
- Conclusions

# Introduction

- Copper films have draw great interest to fabricate the printed circuit boards, electronic devices such as sensors, wearable electronics, batteries, and Radio Frequency Identification (RFID) tags, and electric lead in narrow bezel touch screen owing to their high electrical conductivity in the electronic industry

# *Introduction*

- A two-chamber galvanic cell enabled the simultaneous study of both oxidation and reduction processes involved in electroless copper deposition was investigated before. Electrochemical impedance spectroscopy (EIS) results interpreted with regard to other recent experimental studies for copper deposition in the presence of polyethylene glycol and $Cl^-$ were studied by others.

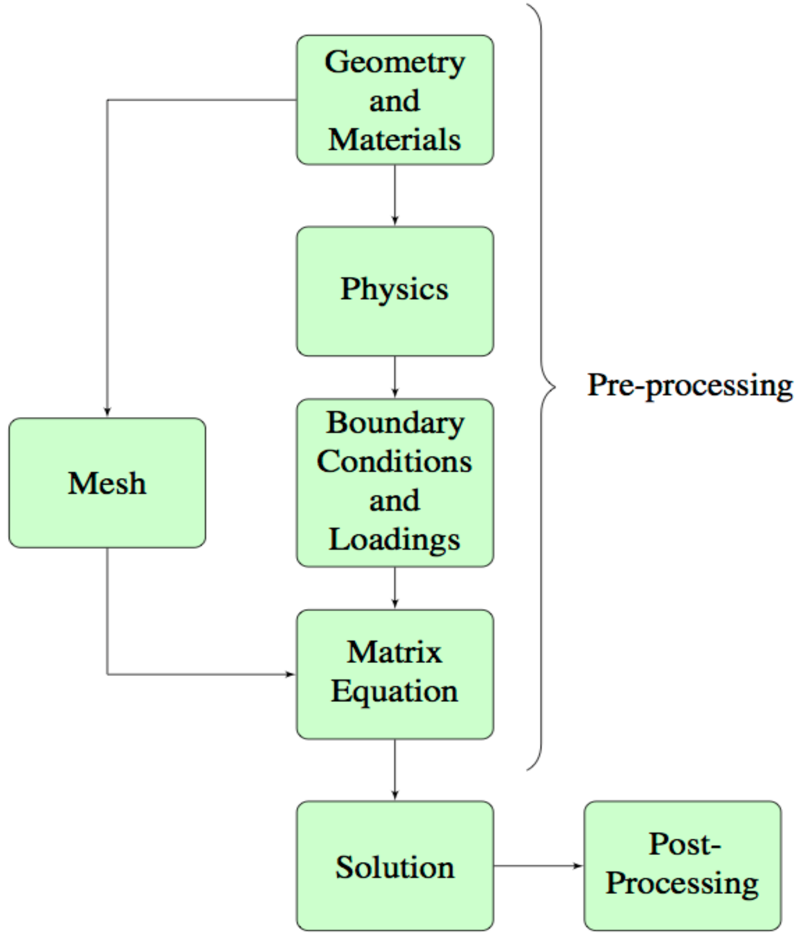
# Introduction

- Galvanostatic studies of the kinetics of deposition and dissolution in the copper + copper sulphate system was presented by other researchers.

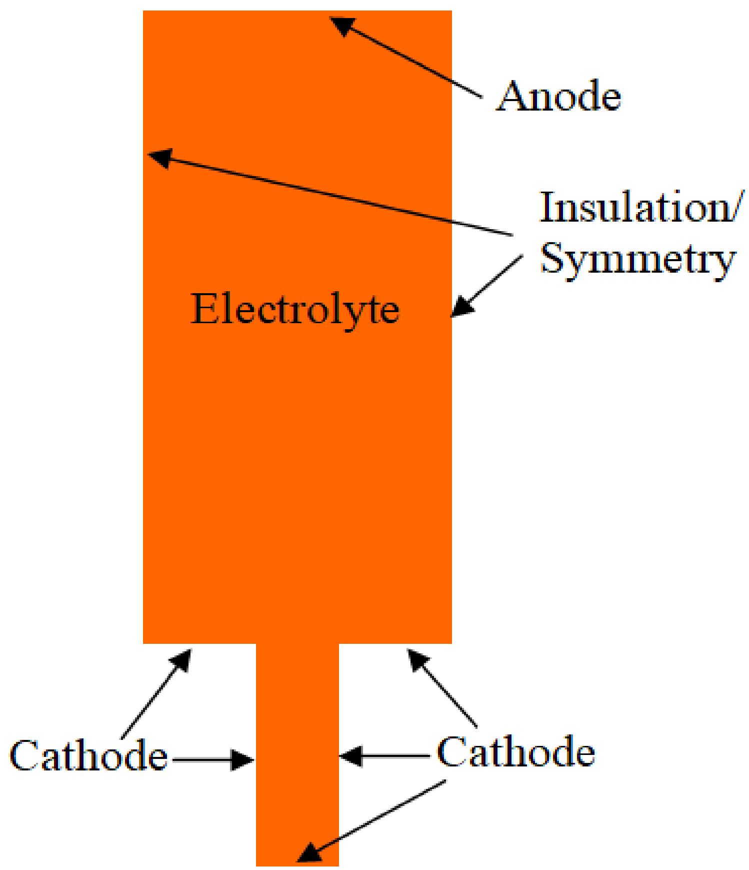
## Aim

- Design the electroplating of copper in a microcavity typically found in the plating of copper onto circuit boards.
- Investigate the influence of the cavity on the plating result using the finite element method (FEM) with COMSOL multiphysics package.

# The steps in COMSOL modeling



# Cross section of the Model



# Formulas for the model

$$\vec{N}_{\mathbf{i}} = -\left( D_i \nabla c_i + z_i u_i F c_i \nabla \phi_i \right)$$

$$Cu^{+} = Cu^{2+} + e^{-}$$

$$Cu = Cu^{+} + e^{-}$$

$$\frac{\partial c_i}{\partial t} = -\nabla \bullet \vec{N}_{\mathbf{i}}$$

$$\sum_{i=0}^{n} z_i c_i = 0$$

$$i_{ct} = i_0 \left\{ e^{\left(\frac{1.5 F \gamma}{RT}\right)} - \left( \frac{c_{Cu^{2+}}}{c_{Cu^{2+},ref}} \right) e^{\left(-\frac{0.5 F \gamma}{RT}\right)} \right\}$$

$$\eta = \phi_{S,0} - \phi_1 - \Delta \phi_{eq}$$

# Formulas for the model

$$\vec{N}_{Cu^{2+}} \bullet \vec{a}_n = \frac{i_0}{2F}\left\{ -e^{\left(\frac{-1.5F\left(-\phi_{s,cat}+\phi_1+\Delta\phi_{eq}\right)}{RT}\right)} + \left(\frac{c_{Cu^{2+}}}{c_{Cu^{2+},ref}}\right) e^{\left(\frac{0.5F\left(-\phi_{s,cat}+\phi_1+\Delta\phi_{eq}\right)}{RT}\right)} \right\}$$

$$\vec{N}_{Cu^{2+}} \bullet \vec{a}_n = \frac{i_0}{2F}\left\{ -e^{\left(\frac{-1.5F\left(-\phi_{s,an}+\phi_1+\Delta\phi_{eq}\right)}{RT}\right)} + \left(\frac{c_{Cu^{2+}}}{c_{Cu^{2+},ref}}\right) e^{\left(\frac{0.5F\left(-\phi_{s,an}+\phi_1+\Delta\phi_{eq}\right)}{RT}\right)} \right\}$$

# Formulas for the model

$$\vec{N}_{Cu^{2+}} \bullet \vec{a}_n = 0$$

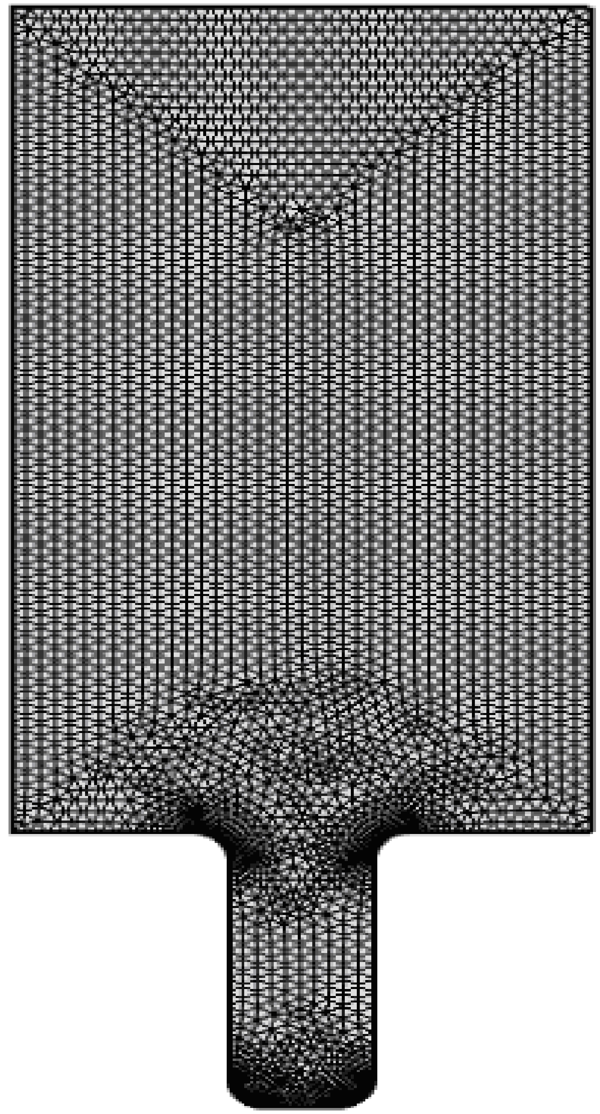
$$c_{SO_4{}^{2-}} = c_0$$

$$\vec{N}_{SO_4{}^{2-}} \bullet \vec{a}_n = 0$$

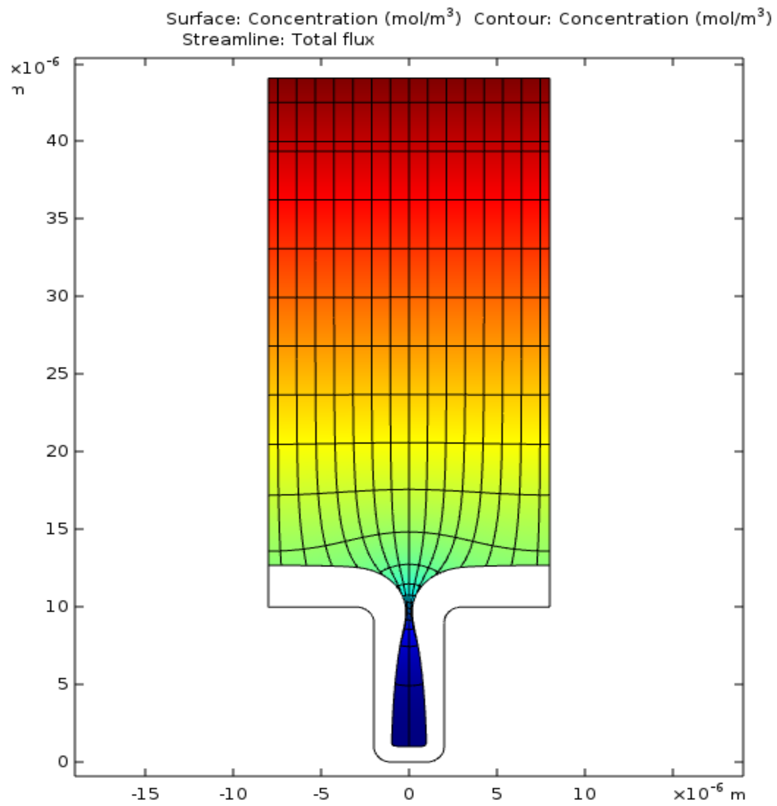
$$Cu = Cu^{2+} + 2e^-$$

$$c_{Cu^{2+}} = c_0$$

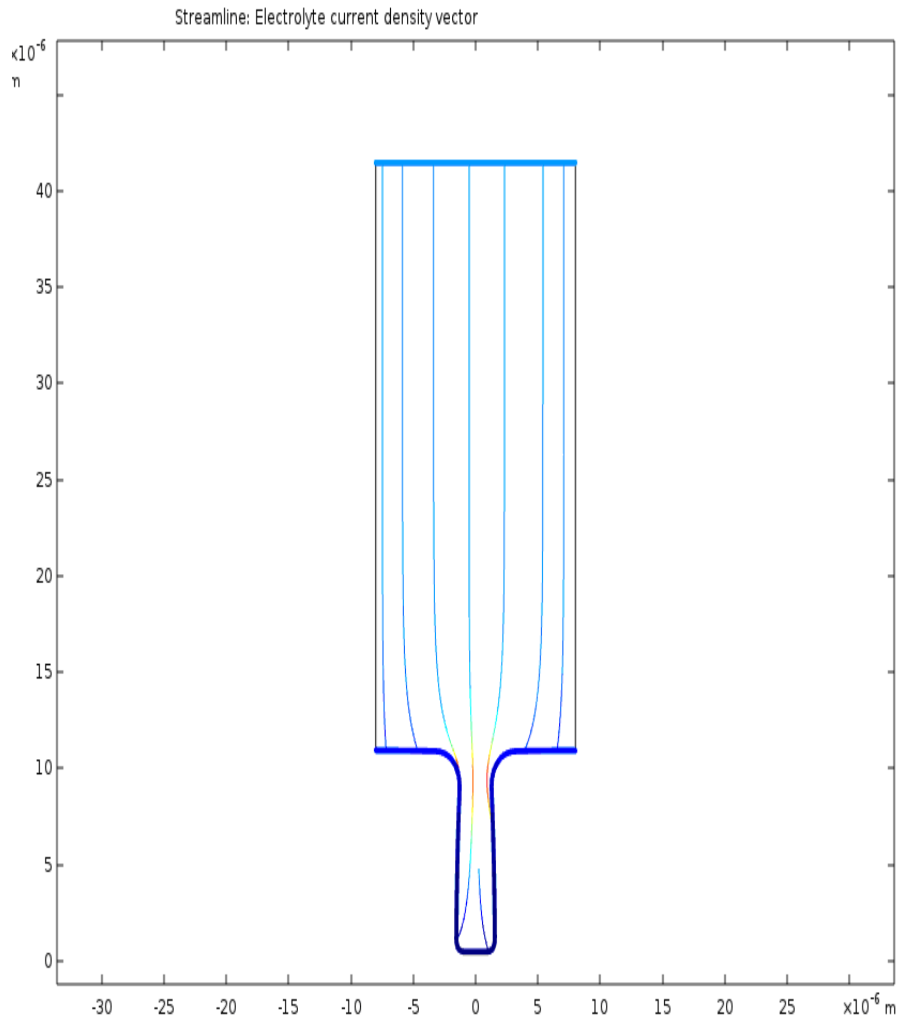
# ***Mesh of the model***



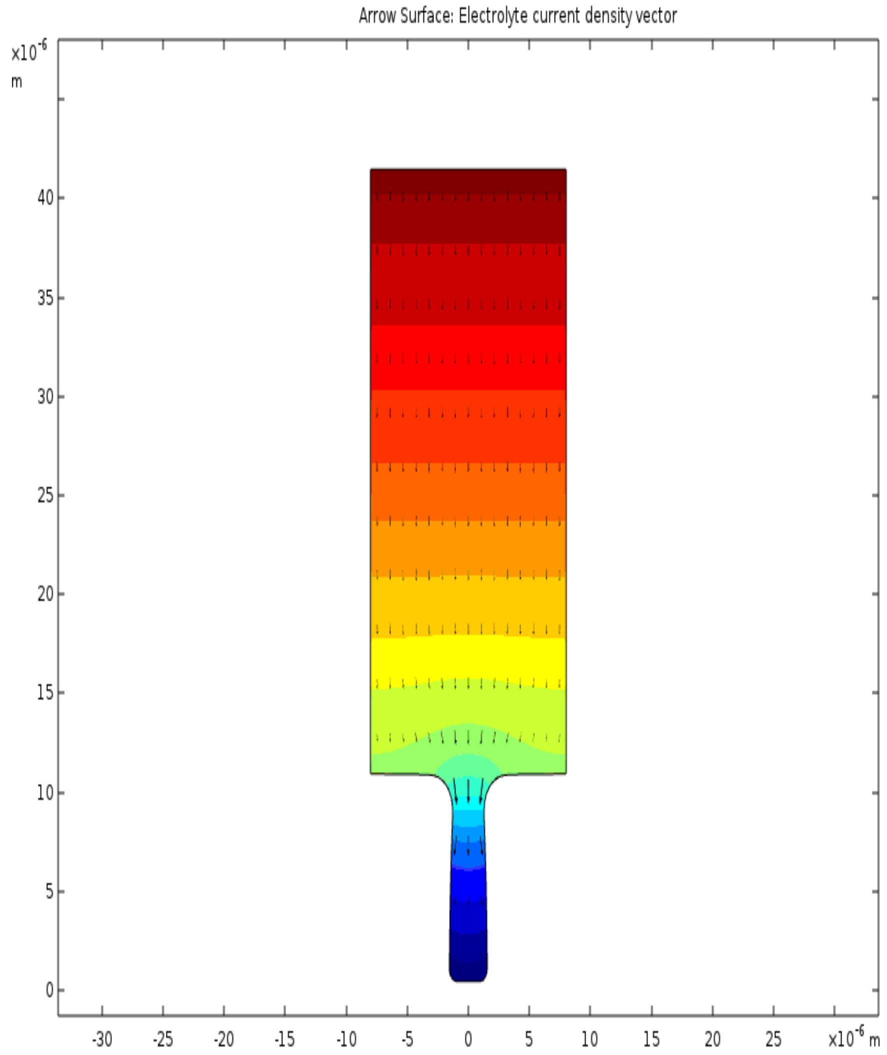
# Surface concentration of the copper ion



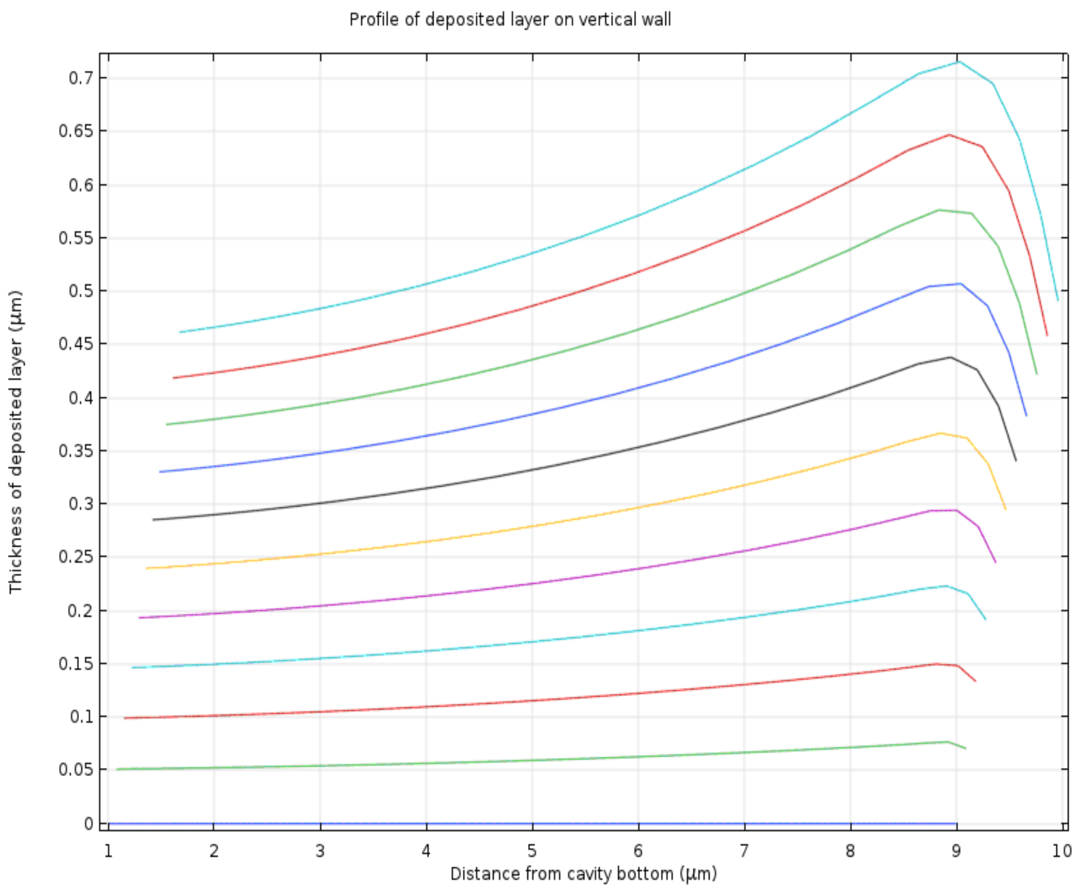
# Stream Line of the model



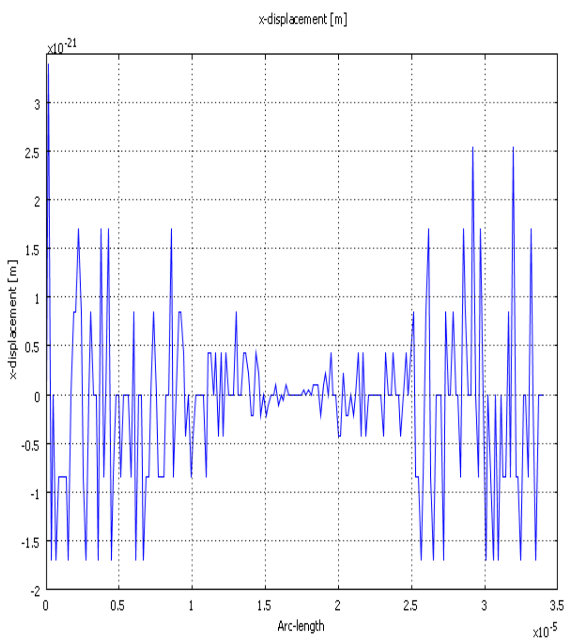
# Arrow surface of the model

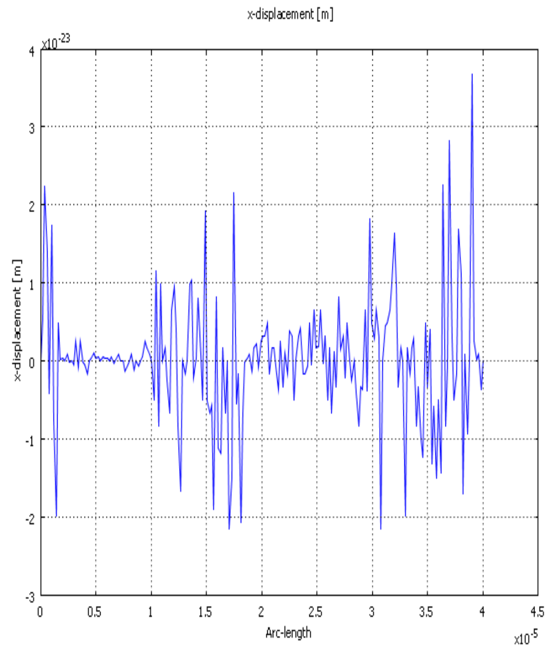


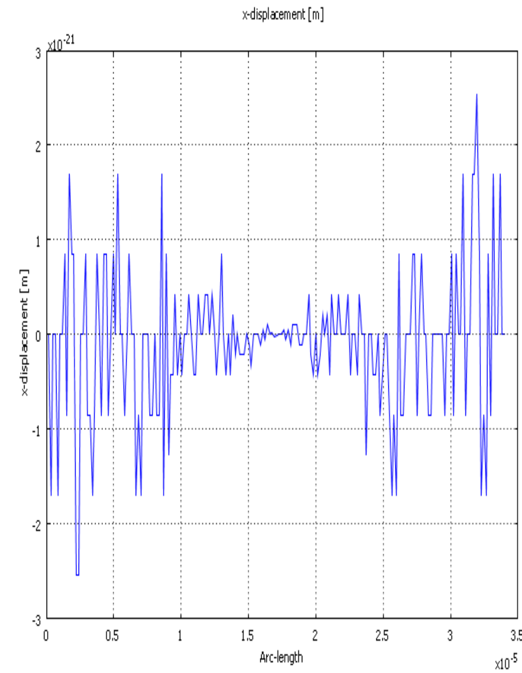
# *Thickness of the deposition along the vertical cathode boundaries*

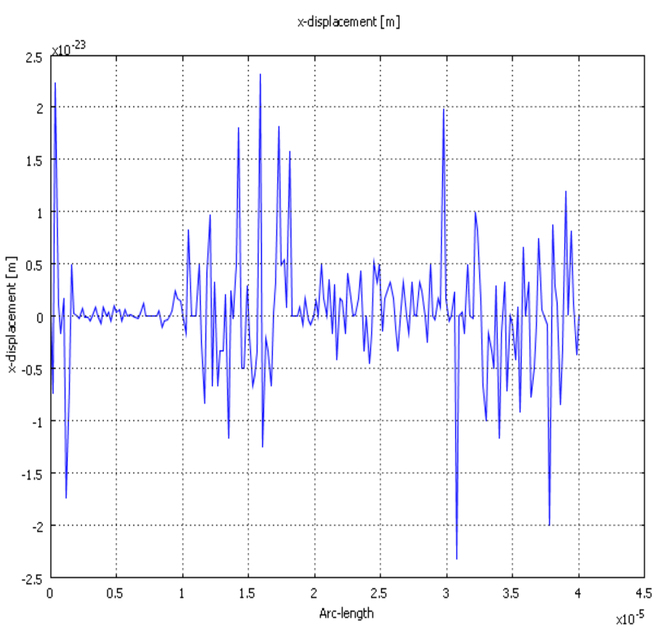


# Analysis of potential distribution of the model



# Conclusions

•This Research has demonstrated the use of the FEM method COMSOL multiphysics to 2-D model of the electroplating of copper in a microcavity typically found in the plating of copper onto circuit boards.

# Conclusions

- We successfully illustrated the use of moving meshes for plating processes and the influence of the cavity on the plating result. The results obtained in this research are encouraging and motivating for further study.

***Thanks***

***Q & A***