# ELECTRICAL CHARACTERIZATION OF BIOLOGICAL CELLS ON POROUS SUBSTRATE USING COMSOL MULTIPHYSICS

D. Mondal* and C. RoyChaudhuri

**Department Electronics and Telecommunication Engineering,
Bengal Engineering and Science University, Shibpur,
Howrah-711103**

*email: debasismondal82@gmail.com

*Presented by*

**Debasis Mondal**

COMSOL
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# INTRODUCTION

- ❖ **Dynamic electrical characterization during cell growth is required as non invasive and label free method to understand the growth kinetics of cells.**

- ❖ **The physiological behavior of the cells and their corresponding molecular expressions has significant effect on the cell membrane and cytoplasm conductivity and dielectric constant.**

  - ➢ **Electrical Characterization of cells is important for monitoring different cellular activities like cell adhesion, spreading, proliferation of cell in real time .**

# MOTIVATION

- ❖ Electric cell substrate impedance sensing (ECIS) platform first reported by Giaever and Keese (*Proc. Natl. Acad. Sci., 1984*) is used to study various cell biological processes like cell attachment, spreading, cell growth, cell apoptosis (***Biosensors and Bioelectronics, 2010, Eur Respir J, 2010, Biosensors & Bioelectronics, 2011, Biosensors & Bioelectronics, 2012, J Biomed Nanotechnol, 2013***).

- ❖ Axonal outgrowth of Dorsal Root Gangiala (DRG) on smooth and porous silicon surfaces has been studied. ***(IEEE Trans. On Biomedical Engineering, 2008).*** The adherence and subsequent viability of rat neuronal B50 cells has been carried out on the nanostructured porous silicon **(Sensors and Actuators A, 1999 ).**

- ➢ **ECIS platform has already been used to monitor different cellular activities. But the different stages of growth cannot be distinguished apparently. Extensive models have to be used to extract the cell parameters at different stages.**

- ➢ **So far, different flat substrates are used for dynamic electrical characterization of biological cells. But porous silicon substrate have not been investigated yet.**

# OBJECTIVE

- **To study the gross electrical characterization of biological cells on novel porous substrate using COMSOL Multiphysics.**

- **To develop a novel porous structure for cell growth monitoring.**

# DESIGN AND SIMULATION USING COMSOL MULTIPHYSICS

## Rectangular electrode

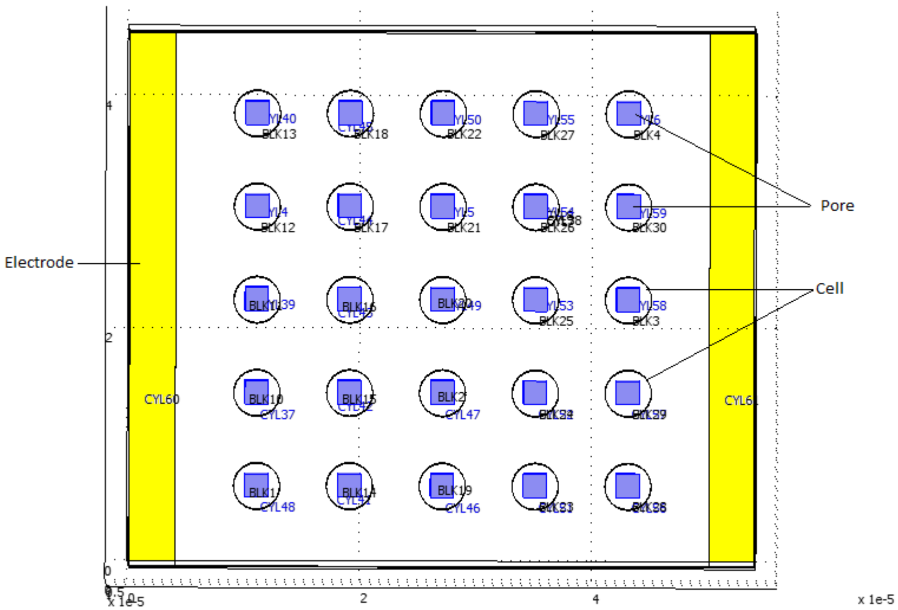



Figure 1. Top view of cells on top of the pores with rectangular electrode

## Circular electrode

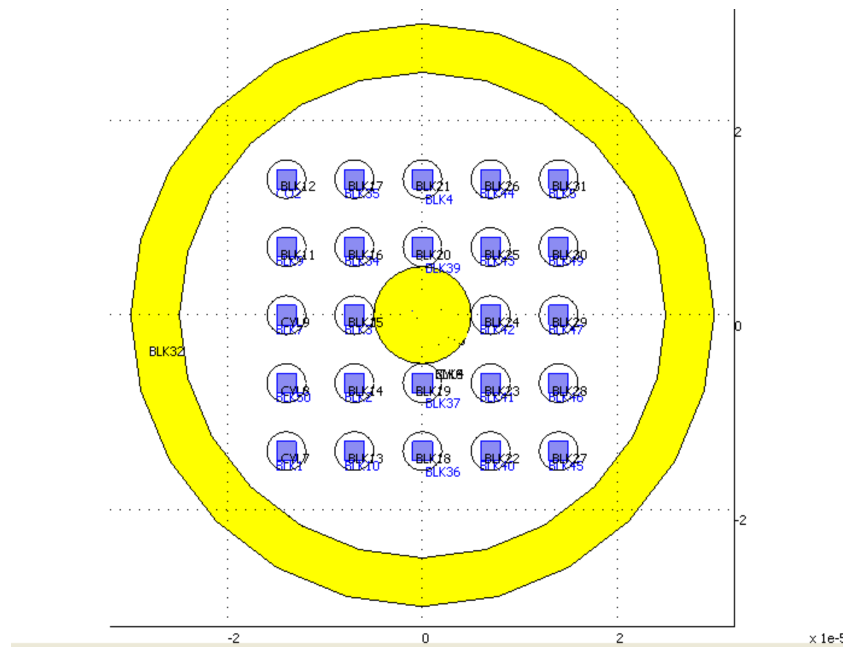



Figure 2. Top view of cells on top of the pores with circular electrode

**Contd.**

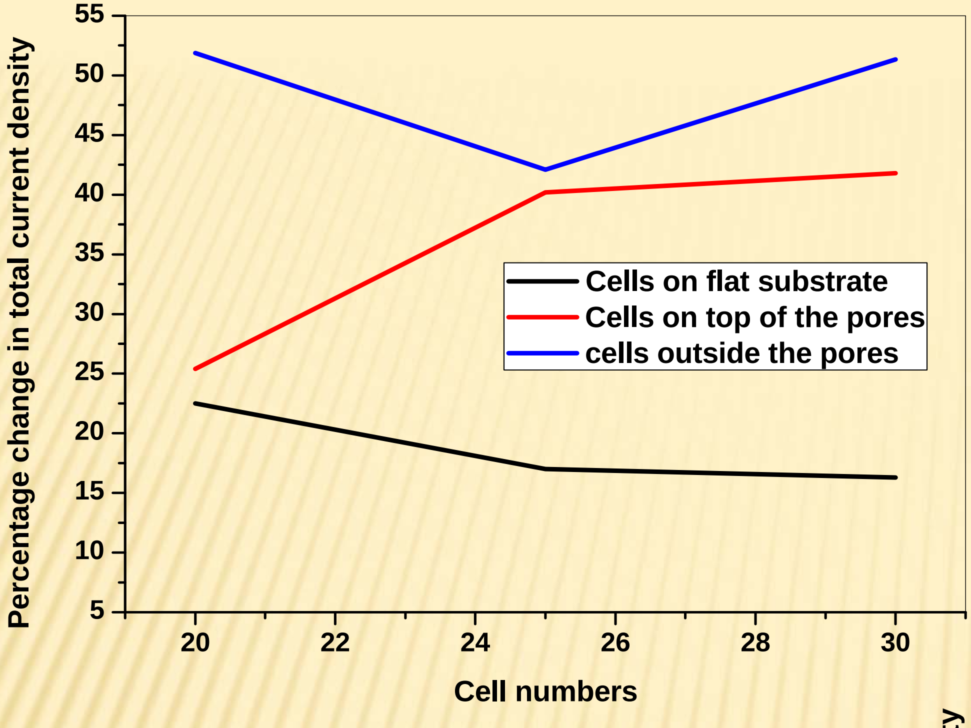
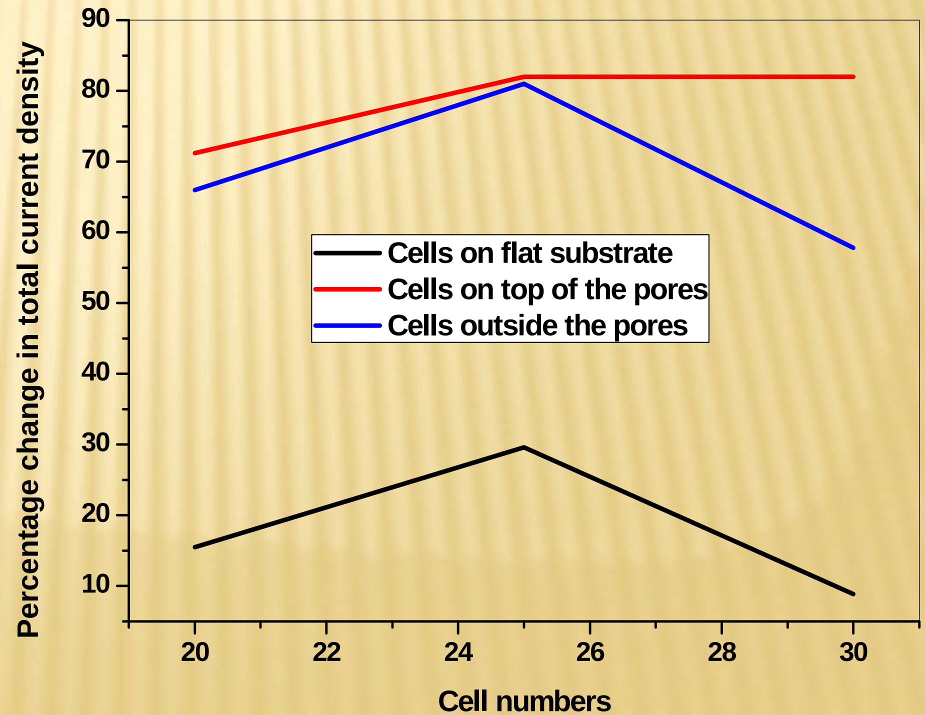



**Figure 3. Percentage change in total current density for rectangular electrode**

**Figure 4. Percentage change in total current density for circular electrode**



# MATERIALS AND METHODS

## Device Fabrication

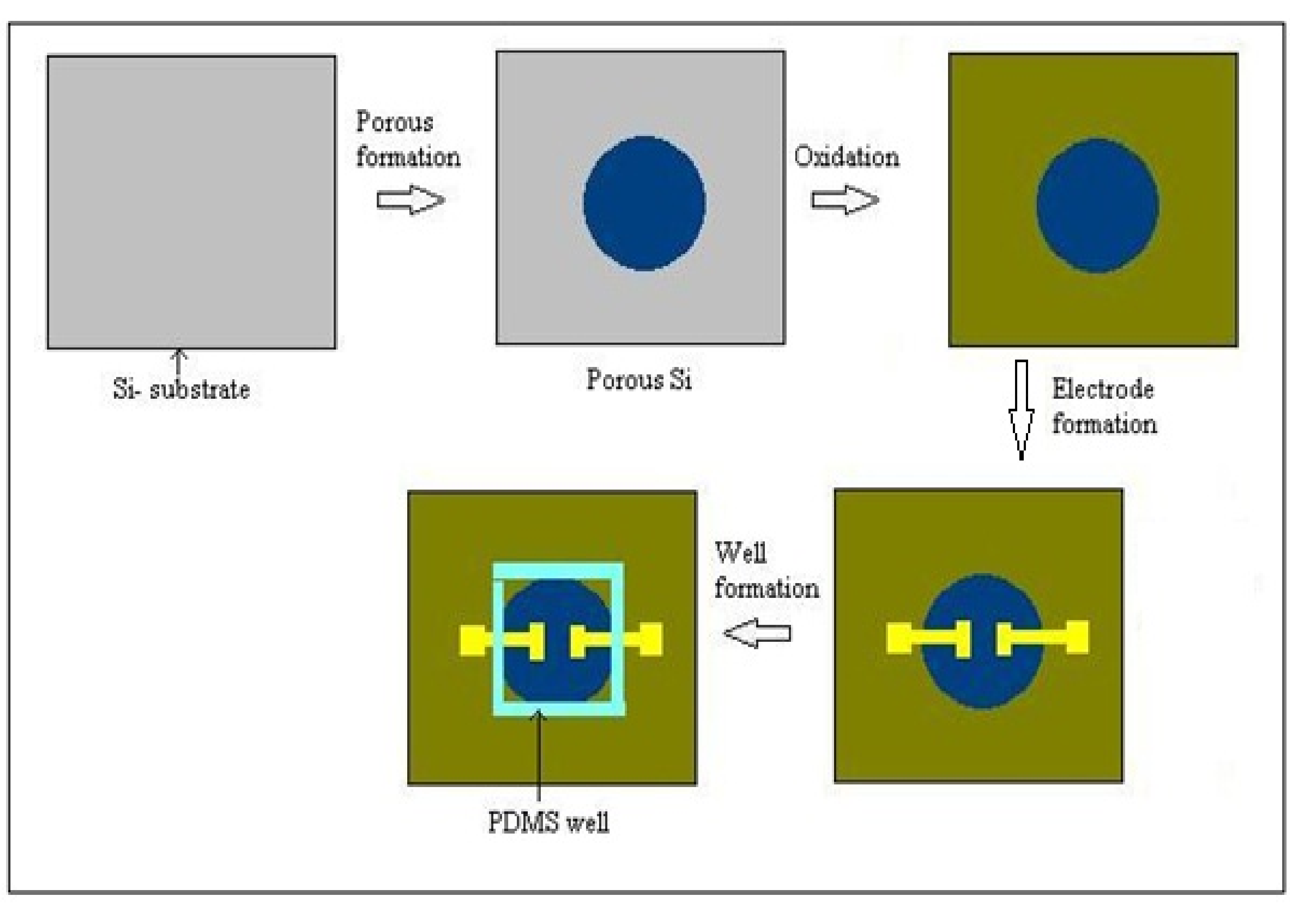



Figure 5. Process flow of device fabrication

Contd.

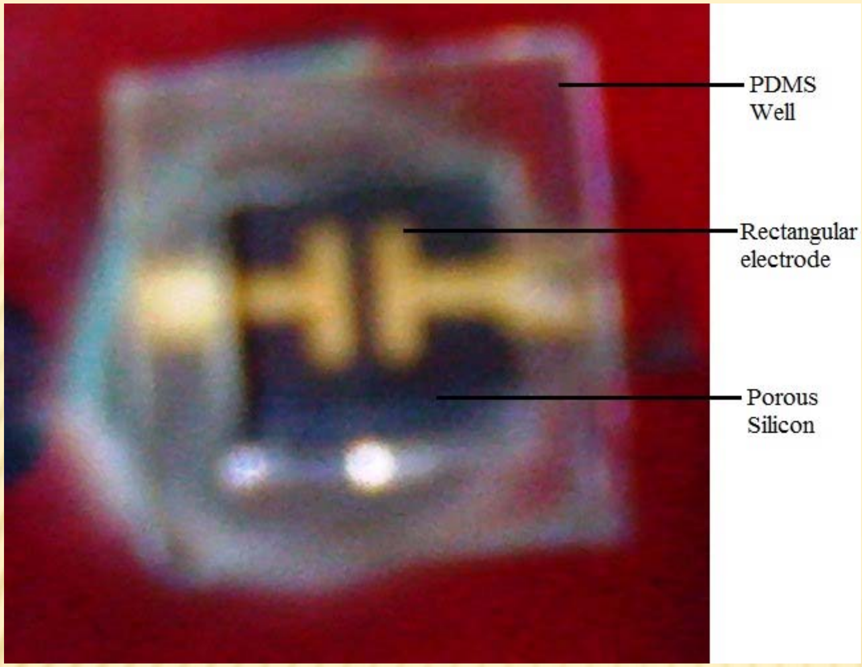



Figure 6. Photograph of the porous silicon device

## Fabricated Device

## Cell Preparation

Cell seeding and incubation → After confluence → Trypsinization → Centrifugation for 2 minutes at 2000 rpm → Discard the media and resuspend the cell palette

# RESULTS AND DISCUSSIONS

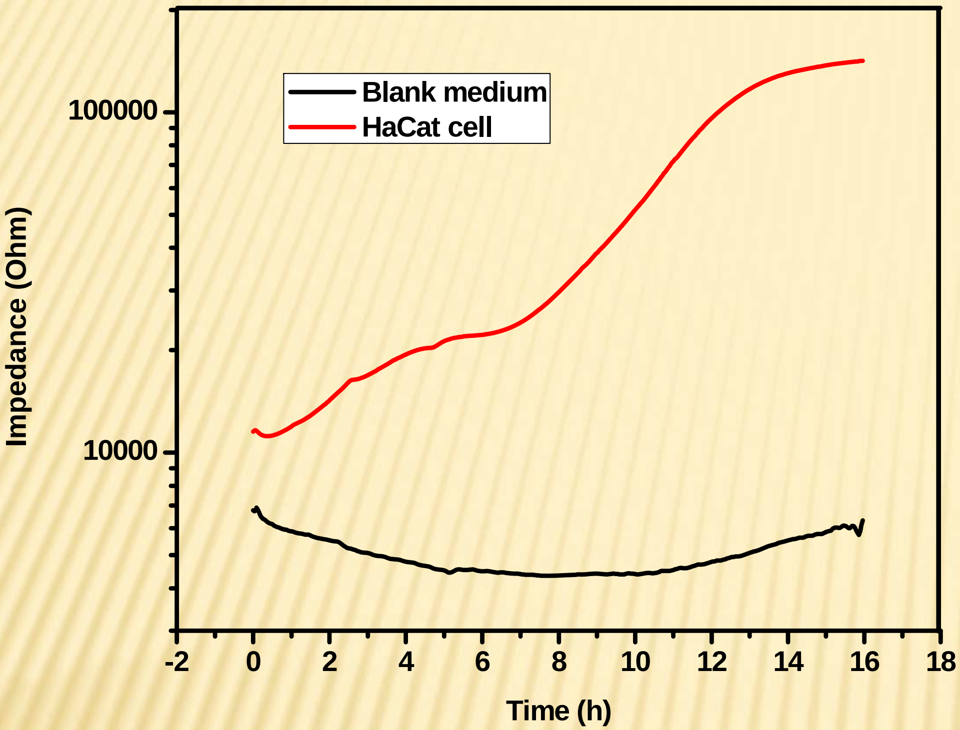



**Figure 7. Impedance variation during cell growth with time at 4 KHz.**

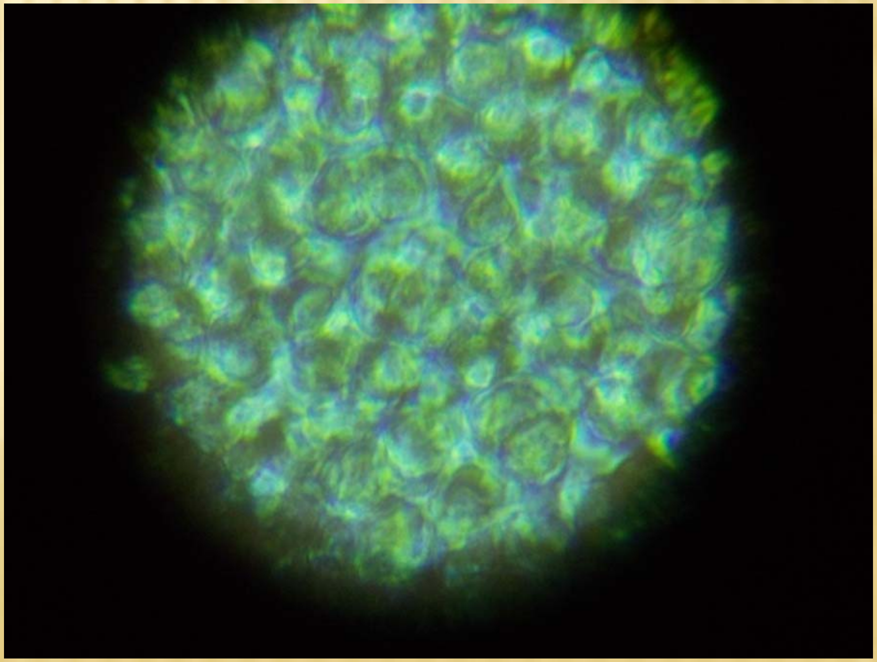


**Figure 8. Optical microscopic view of confluent layer of keratinocytes (HaCat) cells after 16 hours from starting the experiment**

# CONCLUSIONS

- **Percentage change in current density is greater in porous substrate than that of flat substrate observed from COMSOL simulation.**

- **The novel porous silicon substrate has the potential to provide the information about the impedance variation with time during cell growth.**

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- DST, Govt. of India

# REFERENCES


1. *Giaever. I and Keese, Proc. Natl. Acad. Sci., Vol. 81, pp. 3761-3764, 1984.*
2. *L. Renea Arias, Carla A. Perry, Liju Yang, Biosensors and Bioelectronics, 25 (2010) 2225–2231*
3. *I.H. Heijink, S.M. Brandenburg, J.A. Noordhoek, D.S. Postma, D-J. Slebos and A.J.M. van Oosterhout, Eur Respir J 2010; 35: 894–903*
4. *J. Müller, C. Thirion and M.W.Pfaffl,_Biosensors & Bioelectronics, Vol.26, pp.2000-2005, 2011.*
5. *Reitinger S, Wissenwasser J, Kapferer W, Heer R, Lepperdinger G, Biosens Bioelectron, 2012 Apr 15;34(1):63-69*
6. *Tran TB, Nguyen PD, Um SH, Son SJ, Min J, J Biomed Nanotechnol, 2013, 9(2):286-90*
7. *Fredrik Johansson, Martin Kanje, Cecilia Eriksson Linsmeier, and Lars Wallman, IEEE Trans. On Biomedical Engineering, Vol. 55,pp. 1447-1449,2008*
8. *S.C. Bayliss, L.D. Buckberry, I. Fletcher, M.J. Tobin, Sensors and Actuators A, 74 ,1999 ,139-142*
9. *I. Giaever and C. R. Keese, "Micromotion of mammalian cells measured electrically", Proc. Natl. Acad. Sci.,vol.88, pp.7896-7900,1991.*
10. *C. R. Keese and I. Giaever, "Micromotion A Biosensor that Monitors Cell Morphology with Electrical Fields", IEEE Engineering in Medicine and Biology, vol.13, pp. 402-408,1994.*


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THANK YOU