INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Department of Electronics & Communication Engineering

Invited Lectures

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Lecture #1

Title: **Quantum Effects in Biological and Biomimetic Systems**
Speaker: Dr. Vishvendra Poonia
Date and Time: March 08, 2018; 3.00 pm
Venue: Smart Class Room – ICT Academy (Room No. N-316), ECE Department (via Skype)

Abstract of the talk:

The discovery of sustained quantum effects (coherence and entanglement) in biological systems during last decade has sparked a lot of research activity in the field of quantum biology as it can open new avenues for both fundamental research in quantum sciences and novel technological developments. Two of these biological systems are of particular interest for technological applications – highly efficient charge separation in photosynthetic reaction center and avian magnetoreception i.e. magnetic field sensing ability of the migratory birds. They can give us pointers for efficient solar light harvesting and quantum sensing. The talk will cover my work on the investigation of the role of quantum coherence in these biological systems. The emphasis of the work has been on emulating these bio-systems using solid state systems. We proposed a GaN quantum dot based system to emulate the photosynthetic reaction center and diamond nitrogen vacancy (NV) spin center for emulating the avian magnetoreception. Preliminary results on these solid state systems will also be discussed in the talk.

About the speaker:

Dr. Vishvendra completed his B.Tech. in Electronics and Communication Engineering from Indian Institute of Technology Roorkee in 2012. He was DAAD (German Academic Exchange Service) visiting fellow at German Aerospace Center (DLR), Oberpfaffenhofen, Munich in 2011. In 2012, he received the Institute Silver Medal at IIT Roorkee. After B.Tech., he joined IIT Bombay to pursue Ph.D. in the Department of Electrical Engineering. His Ph.D. research was focused on the investigation of quantum effects in biological systems and their emulation using engineered systems. His research work has featured in reputed journals and popular media. After submitting his Ph.D. thesis in October 2017, he joined the Weizmann Institute of Science, Israel as a postdoctoral fellow where he is currently studying the spin properties of organic molecules grown on semiconductor substrates.

Lecture #2

Title: **Piezoelectric based microelectromechanical resonators for RF communication system**

Speaker: Dr. Abhay S. Kochhar

Date and Time: March 08, 2018; 3.45 pm

Venue: Smart Class Room – ICT Academy (Room No. N-316), ECE Department (via Skype)

Abstract of the talk:

One of many concerns in radio frequency (RF) applications is the overcrowded frequency spectrum, which is dependent on continuous demand of frequency channels for various telecommunication needs. Therefore, the high-performance RF frontend system has become active research to handle such needs effectively. Device level approaches that deliver high-Q and optimum band width, are desirable for voltage amplification and filtering. This has led to the development of piezoelectric based commercial products such as SAW, FBAR, and SMR-BAWs in high volume telecommunication markets, contributing in the ever-growing filter needs. Thanks to the advancement in MEMS, micro-fabrication, and availability of better piezoelectric materials, it was possible to overcome technical challenges and improving device performances such as electromechanical coupling and quality factor, product of two called as Figure of Merit (FoM). However, there is still continuous demand for device level improvement considering the availability of unused frequency spectrum (TV white space) and large bandwidth data transmission requirement (such as in frequency ranges of 5G and mmWave).

Today, I will talk about my research experience in dealing piezoelectric based micro resonators advancing for the above-mentioned RF telecommunication needs. Additionally, I will briefly discuss about the realization of a low power RF radio system, formed by a two-chip solution comprising of a MEMS front-end and a CMOS circuit.

About the speaker:

Dr. Abhay Kochhar received B.E. from Nagpur University, M.Tech. from VNIT Nagpur, and Ph.D. from Tohoku University, Japan. From 2013 to 2015, he worked as post-doctoral research fellow with WPI-AIMR, Tohoku University, Japan. From 2015 to 2016, he was post-doctoral research associate and since 2016, he is working as a research scientist, at Department of Electrical and Computer Engineering with Carnegie Mellon University, USA. He was awarded MEXT (Ministry of Education, Culture, Sports, Science and Technology, Japanese Government) scholarship from 2010-2013. He has won the best paper award at IEEE International Ultrasonic Symposium (IUS) in 2012. His research interests include microfabrication, hetero-integrated systems, piezoelectric materials, etc.

Lecture #3

Title: **Neuromorphic engineering: from devices to circuits for energy-efficient computing and bio-hybrid interfaces**
Speaker: Dr. Bhaswar Chakrabarti
Date and Time: March 08, 2018; 4.30 pm
Venue: Smart Class Room – ICT Academy (Room No. N-316), ECE Department (via Skype)

Abstract of the talk:

The recent resurgence in neuromorphic computation comes in the wake of the traditional Von-Neumann computers reaching their performance limits. Unfortunately most of the efforts until now to develop neuromorphic hardware have been concentrated on using Si based Complementary Metal Oxide Semiconductor (CMOS) technology as the basic building block. To make neuromorphic circuits reach their true potential in terms of efficiency new technologies are needed for the neuromorphic circuit components i.e. the artificial synapses and neurons. In this talk I will introduce some of the novel device technologies, especially resistive switching devices or "memristors" that can be used for neuromorphic applications. Resistive switches are one of the most popular candidates for artificial synapses due to their scalability, simple device structure, ease of 3D integration and high on/off ratios. However, significant challenges especially high power consumption and reliability issues remain that are needed to be addressed. I will discuss about the strategies to develop forming-free low power resistive switches and reduction of device variabilities. Potential applications of resistive switches as well as other novel device technologies such as negative capacitance transistors as artificial neurons will also be discussed. Practical implementations of neuromorphic networks with memristive arrays will be discussed. We will particularly focus on the development of hybrid CMOS/memristor circuits and memristor based "Perceptron" classifier networks. Finally the talk will also deal with the idea of bio-hybrid interfaces utilizing biological neurons interfaced with artificial neural networks. Such hybrid interfaces can be hugely beneficial not only for developing basic understanding of neural connectivity in mammalian brain but also for biomedical applications aimed to treat neurological disorders.

About the speaker:

Dr. Bhaswar Chakrabarti is a post-doctoral scholar at the Institute for Molecular Engineering in the University of Chicago. He is broadly interested in the areas of electronic devices, oxide based high-k dielectric materials for non-volatile memories and neuromorphic computation. His current research is aimed at the investigation of novel material systems for the development of low power artificial synapses. Bhaswar has previously worked as a post-doctoral scholar (2014-2016) at the University of California, Santa Barbara where he was involved in the development of neuromorphic circuits with memristive devices. He was responsible for the first demonstration of a monolithic 3D CMOS-memristor hybrid integrated circuit with the capability to work as a high performance multiply-add engine. His other works at UCSB include development of a multi-layer deep neural network (perceptron) with memristive crossbar arrays. Bhaswar received his B. Tech in Radiophysics and Electronics from the University of Calcutta, Kolkata, India, in 2005 and M. Tech in Nanoscience and Technology from Jadavpur University, Kolkata, India, in 2007. He obtained his Ph.D. in Materials Science & Engineering from the University of Texas at Dallas, Richardson in 2013. His doctoral research primarily focused on the development of low

power forming-free resistive switching memory devices using high-k dielectrics and novel 2 dimensional electrode materials.