Nanobio Technology Enabled Point-of-Care Devices

a) Objective: This course is interesting, advanced and will be highly beneficial to the undergraduate/postgraduate students due to development in most rapidly growing areas of nanoscience and technology today. This course offers basic fundamental knowledge and understanding, and current research progresses on topics in Materials Chemistry, Electrochemistry, Nanoscience, Nanotechnology, and Nanobiotechnology and their applications in disease diagnosis, environmental field monitoring, food safety, and security. Over the years, there are increasing needs for the development of simple, cost-effective, portable, integrated biosensors that can be operated outside the laboratory by untrained personnel. However, to reach this goal a reliable sensor technology based on printed electronics must be developed. Maximum conventional enzyme-based biosensors suffer from low signal amplification and complicated detection protocol. Signal amplification is an important tool for the accurate measurement of biomarkers in their very early stage. In this course I will teach the challenges for the development of a point-of-care-test platform for early stage diseases detection in serum or blood (also non-invasive testing in saliva, sweat, or in urine) describing fundamental aspects, developments and their contribution to the area of biosensor relating relevant aspects of the development of sensors. The main goal of this course is to use the fundamental knowledge of signal amplification and printed electronics in a portable device for simple and effective point-of-care testing for early stage disease diagnosis before the extreme stage and can save the patient life.

Participants will also develop their knowledge in the following areas:

1. Why nanomaterials are necessary for early stage biomarker detection in clinical samples.
2. All Nanomaterials is the high specific surface thus already enabling the immobilization of an enhanced amount of bioreceptor units. The simple and efficient methods for the biofunctionalization of nanomaterials will be taught.
3. The beneficial properties of nanostructured carbons such as carbon nanotubes (CNT) or graphene made them a widely used material as electronic or electrochemical transducer in biosensor devices. In particular, CNT possess the outstanding combination of nanowire morphology, biocompatibility and electronic properties. The electrode surface modification of CNT or graphene and their use for signal amplification in biosensor will be taught. Also other nanomaterials will be discussed.
4. Students will learn the new Lab-on-PCB devices for biomedical diagnostics. Commercialization of lab-on-a-chip devices is currently the "holy grail" within the μTAS research community. The major inhibition factor lies in the lack of an established commercial manufacturing technology. The lab-on-printed circuit board (lab-on-PCB) approach helps to solve these issues.

b) Contents:

Introduction and basic concept of point-of-care diagnosis, Analytical Chemistry with Biological applications and their mechanistic studies in diagnosis: thermodynamics, chemical kinetics, rate constant. Nanobiomaterials: fundamental concept. Nanomaterials for early stage biomarker detection, synthesis and characterization of Nanoparticles and their use for Biosensors and Biodevices, Biofunctionalization of nanomaterials, beneficial properties of nanomaterials for diagnosis. Basic electrochemistry tools used in diagnostics. Signal amplification chemistry for higher signal-to-background ratios: Redox Cycling amplification methods, electrode surface modification with nanomaterials. Lab-on-a-chip devices for

biomedical diagnostics, Multiplex diagnostic microsystem development for rapid quantification, Non-Invasive approach, Printed bioelectronics. New detection systems for POCT and integration of highly sensitive Biosensors to mobile devices: Wash-free detection, label-free detection, Lab-on-Printed circuit board, wearable biosensors, smart phone-based platform, disposable self-powered POCT Devices. Device characterization and challenges, commercialization of biosensor and biodevices, environmental field monitoring, food safety, and security.

There will be several Lab experiments and visit for this course.

Text book: -

1. David Wild, The Immunoassay Handbook, Elsevier Science, 4th ed. 2013

2. Joseph Wang, Analytical Electrochemistry, John Wiley & Sons, Inc. 3rd ed. 2006

3. Peter B. Luppa and Ralf Junker, Point-of-Care Testing: Principle and Clinical Applications, Springer, 1st ed. 2018.

References:

1. V. Gubala et al. "Point of Care Diagnostics: Status and Future", Anal. Chem. 2012, 84, 487–515.
2. M. Yang et al. "Flexible and Disposable Sensing Platforms Based on Newspaper", ACS Appl. Mater. Interfaces 2016, 8, 34978-34984.
3. X. Xiao et al. "Tackling the Challenges of Enzymatic (Bio) Fuel Cells", Chem. Rev. 2019, 119, 9509−9558.

4. X, Liu et al. "Smartphones for Cell and Biomolecular Detection", Ann. Biomed. Eng. 2014, 42, 2205–2217.

Similar Courses:

1. SUBJECT NO-CY60019, SUBJECT NAME- Electroanalysis LTP- 3-0-0,CRD- 3

2. SUBJECT NO-CY60107, SUBJECT NAME- Chemistry of Nanomaterials LTP- 3-0-0,CRD- 3

Co-ordinators/Visiting Faculties:

		
Prof. Gorachand Dutta IIT Kharagpur	**Prof. Bernhard Wolfrum** TU Munich, Germany	**Dr. Joachim Wiest** cellasys GmbH Kronburg, Germany

Prof. Gorachand Dutta, is an Assistant Professor with the School of Medical Science and Technology, Indian Institute of Technology Kharagpur. He received M.Sc. degree in Chemistry from Indian Institute of Technology, Guwahati, India. His research interests include the design and characterization of portable biosensors, biodevices and sensor interfaces for miniaturized systems and biomedical applications for point-of-care testing. He received his Ph.D. in Biosensor and Electrochemistry from Pusan National University, South Korea, where he developed different class of electrochemical sensors and studied the electrochemical properties of gold, platinum, and palladium based metal electrodes. He completed his Post-doctoral fellowships in the Department of Mechanical Engineering, Michigan State University, USA and Department of Electronic and Electrical Engineering at University of Bath, UK. During his research tenure in USA and UK, Dr. Dutta invented an enzyme-free, disposable miniaturized immunosensor chip using micropatterned electrode and wash-free method for the development of mobile phone-based platforms for fast and simple point-of-care testing of infectious and metabolic disease biomarkers. He has expertise on label-free multichannel electrochemical biosensors, electronically addressable biosensor arrays, aptamer- and DNA-based sensors and surface bio-functionalization. Also his focused areas: (1) integration of biosensors with fuel cell for self-powered biodevices, (2) low-cost, fully integrated biosensor devices using Lab-on-Printed Circuit Board (PCB) approach, (3) enzyme based immunosensor (ELISA), (4) ultra-sensitive biosensors using magnetic bead assays, nanoparticles, CNT, dendrimer, (5) Lab-on-a-Chip devices for biomedical diagnostics, (6) bio-nanotechnology for drug delivery, (7) microfluidics.

Prof. Bernhard Wolfrum

The research of Professor Wolfrum focuses on neuro- and bioelectronics. In particular, he develops electrochemical sensor arrays and interfaces for mapping chemical cues and stimulating signals in cellular networks. His goal is to establish neuroelectronic hybrids and systems for on-chip neuroscience as well as bioelectronic medicine. To this end, he employs microfabrication techniques, inkjet-printed electronics, 3D printing, and microfluidic cell culture methods. Professor Wolfrum studied physics in Göttingen and Santa Barbara (UCSB) before obtaining his PhD at the University of Göttingen in 2004. He afterwards conducted postdoctoral research at the Institute of Bio and Nanosystems, Forschungszentrum Jülich, and the Kavli Institute of Nanoscience, University of Delft . From 2009 until 2015, he led a Helmholtz Young Investigator group at the Peter Grünberg Institute, Forschungszentrum Jülich. He lectured as a junior professor at RWTH Aachen from 2011 until starting at TUM in 2015. In 2017, he conducted research as a visiting associate professor at Tohoku University in Sendai.

Dr. Joachim Wiest

Joachim Wiest was trained as a skilled worker in communication electronics at German Telekom AG. Later, he studied electrical engineering and information technology at Technische Universität München (TUM) and received the Dipl.-Ing. Univ. in 2003. At TUM he finished a doctorate on dissolved oxygen sensors for lab-on-chip systems in 2008 and received the venia legendi for “Systems engineering of microphysiometry” in 2022. Since 2007 he is founder and chief executive officer of cellasys GmbH which offers system solutions for microphysiometry. He is member of IEEE (2013: senior member; 2021: Executive committee of German section), EUSAAT (2013 – 2017: Audit committee), VDE, DECHEMA, Gesellschaft für Toxikologie (GT), Bund der Freunde der Technischen Universität München e.V. and German Animal Welfare Federation. His main field of activity is the interdisciplinary connection of engineering and life sciences.