

EEE 4434/ Nanobiotechnology

Credits: 3 credits

Textbook, title, author, and year: No textbook is required

Reference materials:

Mauro Ferrari Ph.D., Abraham P. Lee, L. James Lee: BioMEMS and Biomedical Nanotechnology, ISBN: 978-0-387-25563-7 (Print) 978-0-387-25842-3 (Online), 2006

Iqbal, Samir M., Bashir, Rashid (Eds.): Nanopores Sensing and Fundamental Biological Interactions, ISBN 978-1-4419-8252-0, 2011

Research Articles:

M. Sher, R. Zhuang, V. U. Demirci, W. Asghar, "Paper-based analytical devices for clinical diagnosis: recent advances in the fabrication techniques and sensing mechanisms," Expert Review of Molecular Diagnostics, Accepted, DOI: 10.1080/14737159.2017.1285228 (2017)

W. Asghar, H. Shafiee, V. R. Sah, S. Guo, R. El Assal, F. Inci, A. Rajagopalan, M. Jahangir, R. M. Anchan, G. L. Mutter, M. Ozkan, C. S. Ozkan, and U. Demirci "Toxicology Study of Single-walled Carbon Nanotubes and Reduced Graphene Oxide in Human Sperm," Scientific Reports, vol 6, article 30270 (2016)

K. Rappa, HF Rodriguez, GC Hakkarainen, RM. Anchan, GL. Mutter, W. Asghar, "Sperm processing for advanced reproductive technologies: Where are we today?", Biotechnology Advances, doi:10.1016/j.biotechadv.2016.01.007 (2016)

M. Safavieh, C. Coarsey, N. Esiobu, A. Memic, J. Mahesh, H. Shafiee, W. Asghar, "Advances in Candida Detection Platforms for Clinical and Point-of-Care Applications", Critical Reviews in Biotechnology, DOI:10.3109/07388551.2016.1167667 (2016)

W. Asghar, M. Yuksekkaya, H. Shafiee, M. Zhang, M. Ozen, F. Inci, M. Kocaculak, U. Demirci, "Engineering long shelf life multi-layer biologically active surfaces on microfluidic devices for point of care applications", Scientific Reports, 6: 21163 (2016)

M. Safavieh, M.K. Kanakasabapathy, F. Tarlan, M. Ahmed, M. Zourob, W. Asghar#, and H. Shafiee#, "Emerging Loop-mediated Isothermal Amplification-based Microchip and Microdevice Technologies for Nucleic Acid Detection", ACS Biomaterials Science and Engineering", vol. 2, no. 3, 2016

W. Asghar*#, R. EL Assal*, H. Shafiee, S. Pitteri, R. Paulmurugan, and U. Demirci#, "Engineering cancer microenvironments for in vitro 3-D tumor models", Materials Today, vol 18, no. 10, (2015)

H. Shafiee, W. Asghar, F. Inci, M. Yuksekkaya, M. Jahangir, M. H. Zhang, N.G. Durmus, U.A. Gurkan, D. R. Kuritzkes, and U. Demirci, "Paper and flexible substrates as materials for biosensing platforms to detect multiple biotargets," Scientific Reports, 5, (2015)9.

W. Asghar, V. Velasco, J.L. Kingslye, M.S. Shoukat, H. Shafiee, R.M. Anchan, G.L. Mutter, E. Tuzel, and U. Demirci, "Selection of functional human sperm with higher DNA integrity and fewer reactive oxygen species," Advanced HealthCare Materials, vol 3. no. 10 (2014)

Specific course information

Catalog description: The sensing and characterization of biological entities, processes and events, with novel nanoscale devices and nano-object mediated modalities, will have immediate and far reaching impacts. This course covers the fundamentals of nanotechnology in biological and biomedical research. The course work is approached from an engineering perspective offering insights on the details of nanoscale fabrication processes as well as cell biology. The basics of biology and chemistry, with focus on how to engineer the behavior of molecules at the nanoscale, are also introduced and analyzed. Concepts and processes related to BioMEMS and microfluidics will also be explained.

Specific goals for the course: To introduce the students to the concepts of nanobiotechnology and its applications in biological and biomedical engineering, pharmaceuticals, diagnostics, and public health. Students will also learn material properties of natural and synthetic materials and their applications in biomedical engineering.

Brief list of topics to be covered:

Introduction to Nanobiotechnology, historical perspective, solid-state fabrication, Moore's law and its implication in bioengineering.

Basic semiconductor materials, Crystal structure, Miller indices, Crystalline materials.

Standard fabrication processes and modules, oxidation (wet and dry), oxide properties, Photolithography

Projection Lithography, Pitch limit and diffraction, Light sources

Doping, Diffusion, Ion Implantation, dry etching, wet etching, Isotropic and anisotropic etching.

Deep reactive ion etching, LPCVD, PECVD, PVD

Trade-offs in lithography, next generation lithography. X-Ray lithography, XPS, Auger electron spectroscopy, EUV lithography, Proximal X-ray lithography

E-beam lithography, Focused ion beam lithography, Projection e-beam and ion beam lithography

Scanning probe lithography, atomic force lithography

Dip pen lithography, AFM lithography by local probe oxidation, STM lithography

Soft lithography, contact printing, PDMS properties

Micro transfer molding, replica molding, PDMS issues, CD based fluidics

Nanoimprint lithography, step and flash lithography

Biomolecules, cells and organelles, chemical structure of phospholipids

Functional groups, structure of nucleic acids, genes, electronics properties of nucleic acids, aptamers

DNA structure and fundamentals, human genome project

DNA microarrays, Integration of bionano, need to biosensing, electronic properties of biomaterials

Molecular sensing, DNA hybridization, Annealing, Polymerase chain reaction (PCR), DNA replication and amplification.

Real-time PCR, SYBR staining, Taqman, Scorpion, RT-PCR, PCR on-chip, microfluidics

Next generation sequencing, ion torrent technology, Solid-state and biological nanopores for DNA analysis

Gene translation and expression (mRNA, tRNA, rRNA)

Types and structure of protein, types of amino acids, surface functionalization with protein and DNA/RNA probes

Nanowires, synthesis, nanowire biosensors

Quantum dot confinement, carbon nanotubes and graphene, synthesis and their applications in biomedical engineering