Microfluidics - Video course

COURSE OUTLINE

This is a basic course on microfluidics at the senior undergraduate and post-graduate level. It covers fundamentals of micro-scale flows and microfabrication. The course also includes design of microfluidic components and few applications of microfluidic systems.

The fundamentals of fluid flows at micro-scale including intermolecular forces, low Re flows, slip theory, capillary flows and electrokinetics are discussed. The principles of microfabrication with silicon and polymer substrates are illustrated. Theory and design of various microfluidic components including micropumps, micromixers, microvalves etc is discussed. Few applications of microfluidic systems are also covered.

COURSE DETAIL

Sl. No.	Topics	No. of lectures (1 hr each)
01	**Introduction** Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.	2
02	**Micro-scale fluid mechanics** Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel.	10
03	**Capillary flows** Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.	2
04	**Electrokinetics** Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electro-osmotic flow, Ideal EOF with back pressure, Cascade electro-osmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP , Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere.	7

NP-TEL

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Mechanical Engineering

Pre-requisites:

Engineering Mathematics

Coordinators:

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	Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.	
05	**Microfabrication techniques** Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer microfabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections.	**7**
06	**Microfluidics components** Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Microvalves, Pneumatic valves, Thermopneumatic valves, Thermomechanical valves, Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of microparticles, design and applications. Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.	**10**
07	**Few applications of microfluidics** Drug delivery, Diagnostics, Bio-sensing.	**2**

References:

1. Nguyen, N. T., Werely, S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002.
   Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
2. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
3. Tabeling, P., Introduction to microfluidics, Oxford University Press Inc., 2005.
4. Kirby, B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.
5. Colin, S., Microfluidics, John Wiley & Sons, 2009.