FUNDAMENTALS OF NANO AND QUANTUM PHOTONICS

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PRE-REQUISITES : Introduction to Semiconductor Devices (108106181 or equivalent), Introduction to Photonics (108106135), Elementary quantum mechanics.

INDUSTRY SUPPORT : Semiconductor Industry

COURSE OUTLINE :

The course objective is to familiarize students to the research frontiers in Nano and Quantum Optics. The course will discuss fundamental principles with emphasis on developing intuitive understanding and developing analytical techniques. This course is primarily designed for post-graduate and PhD research scholars in Photonics. Senior undergraduate students pursuing ECE/EE/Physics or related programs will also benefit by exposure to this frontier area of research. Faculty interesting in expanding their knowledge base and/or prepare for research programs will also find it beneficial.

ABOUT INSTRUCTOR :

Prof. Naresh Kumar Emani is an assistant professor in the electrical engineering department of Indian Institute of Technology Hyderabad. Prior to joining IIT Hyderabad he worked as a Scientist at Data Storage Institute(A*STAR), Singapore and Taiwan Semiconductor Manufacturing Company(TSMC), Hsinchu, Taiwan. He received his MTech degree in Microelectronics from IIT Bombay, and PhD degree from Purdue University. His research interests are in the areas of Dielectric Nanophotonics, Plasmonics, Silicon Photonics and Solar Photovoltaics. Further details can be found on his webpage https://iith.ac.in/~nke/

COURSE PLAN :

Week 1: Introduction to nanophotonics – Why nanophotonics? Review of electromagnetics, Maxwell equations and Wave Optics, Electromagnetic radiation and evanescent waves, the Diffraction limit of light

Week 2: Light-matter interaction - Dielectric function, Kramers-Kronig relationship, Drude-Lorentz and Drude models, Interband and Intraband transitions

Week 3: Plasmonics - Quasi-static limit, nanoparticle as a plasmonic atom, size-dependent absorption and scattering, coupled nanoparticles, plasmon hybridization

Week 4: Dielectric nanophotonics – Photonics in 2D, 1D and 0D semiconductors, Selection rules, Photonic density of states

Week 5: Electromagnetic waves in 1D periodic potential - Scattering from planar interfaces, Photonic bandgaps, Rayleigh anomalies

Week 6: Electromagnetic waves in 2D periodic potential - Electric and magnetic metamaterials, negative refractive index, superlens and hyperlens, Plasmonic and Dielectric metasurfaces

Week 7: Light emitting(active) metamaterials - Optical gain, Radiative and non-radiative transitions, Amplified emission, Lasing threshold, Nano-lasers

Week 8: Nanofabrication of photonic devices – examples from recent literature on nanophotonic devices, Classical to quantum nanophotonics (small dimensions + low intensity/few photons)

Week 9: Photon Statistics - Photonics in the quantum regime, Classification of light by Photons statistics, Super-Poissonian and sub-Poissonian light, photo-detection

Week 10: Photon Anti-bunching - Hanbury-Brown Twiss interferometer, second-order correlation function, photon bunching and anti-bunching, Single-Photon Sources

Week 11: Canonical quantization - Quantum harmonic oscillator, phasor diagrams and quadratures, Vacuum fluctuations, Coherent states, Number-phase uncertainty

Week 12: Resonant light-atom interactions - time-dependent Schrodinger equations, Strong and weak coupling, Rabi-oscillations