20VL023 - Nano-Optics

Course Objective:

The objective of this course is to provide students with

- ✓ To acquire the knowledge of basic sciences required to understand the fundamentals ofNano-optics.
- ✓ To acquire the knowledge of electronic, optical and magnetic properties of optic.
- ✓ To get familiarize with the basic concepts of Statistical and Quantum mechanics

Course Outcome

Upon the completion of this course, students will demonstrate the ability to:

CO1: Understand the photonic band gaps and band-edges

CO2: Understand the light scattering cancellation.

CO3: Analyse the transformation techniques.

CO4: Investigate new technologies for nano optics

Unit I-Fundamentalconcepts:

Wave optics and wave mechanics: Schrödinger and Helmholtzequation, Review of EM theory and FourierOptics, Angular spectrum representation of opticalfields, Resolution limits in classicaloptics, Nano-opticalfields, Optics below the diffractionlimit.

Unit II-Light scattering theory andNanoplasmonics:

Fields and waves in different coordinate systems, solutions of waveequations, Analytical scattering theories: Mie theory of canonicalshapes, Generalized Mie theory, T-matrix and multi-particle scattering theories, Numerical techniques in nano-opticsReview of metal optics, surface Plasmonpolariton, Localization ofplasmon-polaritons,Resonant enhancement of opticalfields.

Unit III-Confined Light and QuantumElectrodynamics:

Canonical quantization of EMfields, Optical Microcavities: weak and strong couplingregimes, Wigner-Weisskopf theory of spontaneousemission, Optical forces, Casimireffect, Local Density of States, Spontaneous emissionenhancement, Cavity Quantum Electrodynamics(Cavity-QED)

Unit IV-Light in complexmedia:

Light in inhomogeneous media: Hamiltonianformulation, Stochastic geometric optics approach and vectorapproach, Eigen value electrodynamics of 1D, 2D, 3D periodicsystems, Photonic band gaps, band-edges and defect states in photoniccrystals, Random media and AperiodicNano-Structures, Anderson lightlocalization

Unit V-Transformation optics:

Coordinatetransformations, Basic concepts of differential geometry (metric tensor, vectors and tensors, the covariant derivative, general differential operators, curvature andgeodesics), Maxwell’s equations in curved spaces and GRINoptics, Unruh effect, “optical black-holes”, design of perfectabsorbers, Geometry of light and Invisibility: active scattering cancellation andcloaking

Reference Books:

- Principles of Nano-Optics (II Edition) by L. Novotny and B. Hecht (Cambridge)
- Theory and computation of electromagnetic fields by Jian-Ming Jin (Wiley)
- Scattering of electromagnetic waves (vol. 1-3) by L. Tsang, J. A. Kong, K. Ding (Wiley)
- Optical properties of photonic crystals by K. Sakoda (Springer)
- Introduction to wave scattering and mesoscopic phenomena by P. Sheng (Springer)
- Geometry and Light by U. Leonhardt and T. Philbin (Dover)
- Cavity Quantum Electrodynamics by Sergio M. Dutra (Wiley)