Basic Information:
Course Title: Fundamentals of Photonics
Lecturer: Prof. DSc. Vera Marinova
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Total Teaching Hours: 30

Annotation (up to 150 words)
This course covers the basic principles of electromagnetic optics and interaction of the light with matter. Sub-topics will focused on a brief introduction of monochromatic waves (interference and diffraction of light), electromagnetic optics (electromagnetic waves, absorption and dispersion of light; slow and fast light in resonant media, optics in magnetic and metamaterials); polarization optics (reflection and refraction of light, evanescent waves, dispersion); optics of anisotropic media (crystal optics, optics of liquid crystals, polarization devices); semiconductor optics (interaction of photons with charge carriers, semiconductor photon sources and devices); principles of electro-optics (electro-optics of anisotropic media, photorefractivity) and non-linear optics (anisotropic and dispersive non-linear media). The purpose of fundamentals of photonics teaching is to introduce some of the current issues of modern technology for development of advanced multifunctional materials (including graphene and 2D materials) and device fabrication that take place in the subwavelength (nanometer) scale.

Course content (brief description by topics or modules)

Fundamental of Photonics (20 academic hours)

I. Fundamental principles and wave optics

1. Nature of light. Ray Approximation in Geometric Optics
2. Wave optics. Monochromatic waves. Interference and diffraction.
3. Electromagnetic theory of light. Monochromatic electromagnetic waves. Absorption and Dispersion.
4. Polarization of light. Reflection and Refraction. Optical activity and Faraday effect

II . Anisotropic media and light control

5. Anisotropy. Propagation of light in an anisotropic media. Optics of Liquid Crystals. Liquid Crystal Display technology.
6. Principles of electro-optics. Modulators. Phase retarders and spatial modulators of light
7. Guided wave optics. Waveguides and optical coupling.

III. Nanophotonics and modern materials

8. Holography and 3D display. Two-beam interference. Photorefractive effect. Introduction to meta-surfaces, meta-holography and meta-lenses.
9. Semiconductor materials: Energy bands, generation and recombination of charge carriers
10. Graphene and transitions metal dichalcogenides (TMDCs) – photodetectors, photodiodes and sensors. Non-centrosymmetric materials for active components in silicon photonics.

Lab Practicum (10 academic hours)

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1. Laser source setup, Beam alignment, Expansion/Spatial filtering, Collimation
2. Assembling optical installations; interference of two beams.
3. Polarization optics, Liquid crystal optics
4. Electrical measurements: Hall effect, sheet resistance, charge carrier mobility
5. Measurement of contact angle, surface free energy
6. Solar simulator and I-V characteristics.
7. Practical introduction to CVD (Chemical Vapor Deposition) processes. Methods for tellurization and selenization (TAC). Synthesis of graphene
8. Transfer and heterostructures: Technology for transfer on pads and precise assembly on van der Vaals heterostructures .

Teaching and assessment methods

Fundamental understanding of light……………………………………………………

Working with light sources

Designing optical systems

Practical introduction of techniques for synthesis and characterizing nanomaterials

Competencies acquired as a result of training (3–5 points)

In person learning

Laboratory exercises with protocols.

Written exam and discussion

Literature:

1. B E A Saleh and M C Teich "Fundamentals of Photonics" (2007)
2. B. D. Guenther "Modern Optics" (2015)
3. Charles Kittel, Introduction to Solid State Physics, 8-th Edition, John Wiley & Sons, Inc, 2005.
4. Pochi Yeh "Optics of Liquid Crystal Displays" Wiley 2010
5. Rolf E. Hummel "Electronic Properties of Materials" 4th Edition Springer, 2012