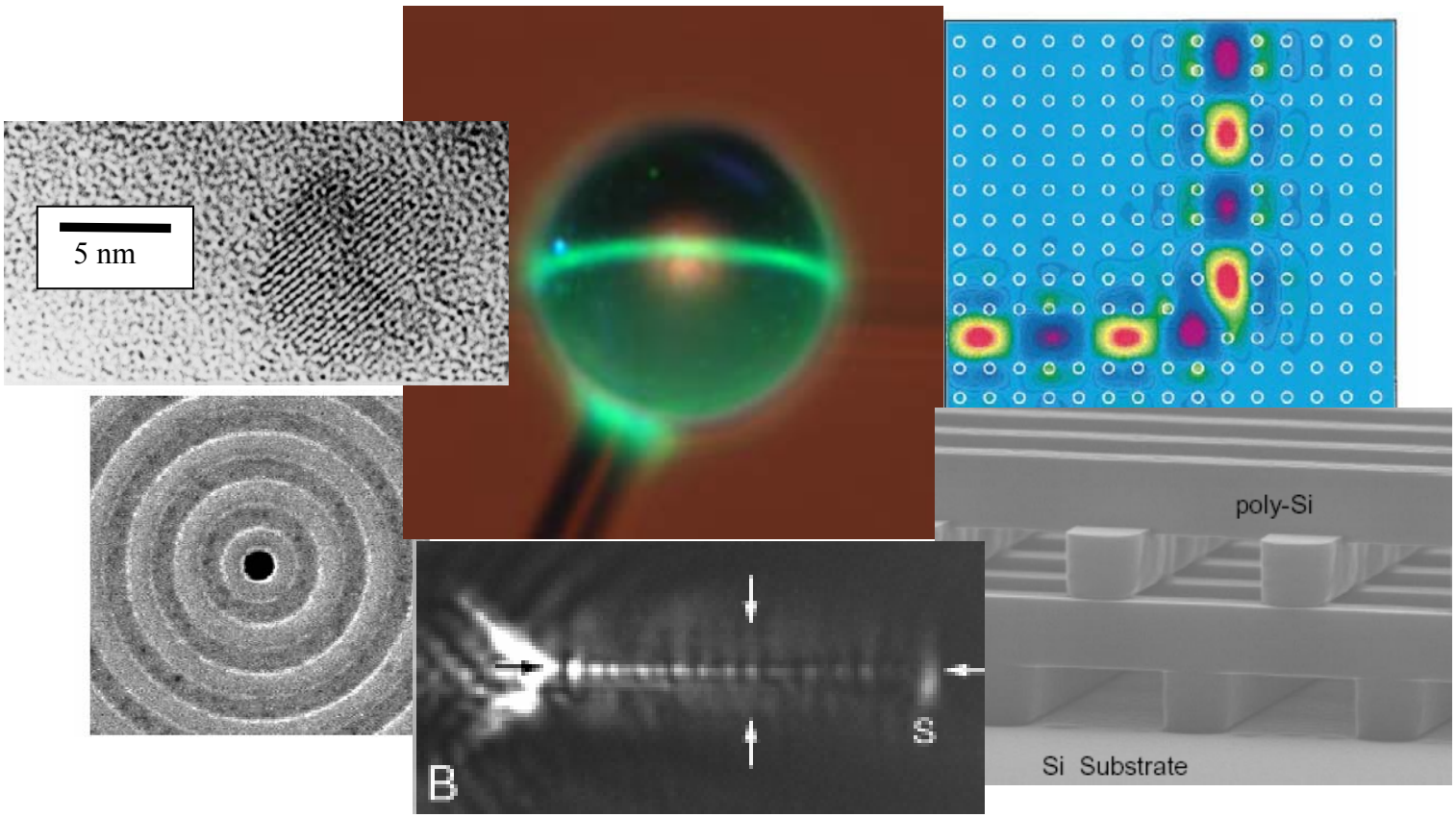
Nanophotonics*

Professor Vladimir M. Shalaev

ECE695S



*)This course was prepared with M. Brongersma and S. Fan from Stanford. There help is highly appreciated.

Nanophotonics

Instructor

Professor Vladimir M. Shalaev
MSEE270 and BRK2295; 494-9855
Email: shalaev@purdue.edu
Office hour: Tue, 2-3pm

Grader

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Course Web page

http://shay.ecn.purdue.edu/~ece695s/ to download lecture notes

Recommended Textbook:

Photonic Crystals: Molding the flow of light.
By Joannopoulos, Meade and Winn, (Princeton University Press, Princeton, 1995).

Near-field optics and surface plasmon polaritons
Editor: Satoshi Kawata (Available online via course webpage)

Grading

30% homework, 30% midterm exam, 40% final (presentation and report)

Overview of the Course

Part I: Introduction to light interaction with matter

Derivation Wave Equation in matter from Maxwell's equations
Dielectric properties of insulators, semiconductors and metals (bulk)
Light interaction with nanostructures and microstructures (compared with λ)

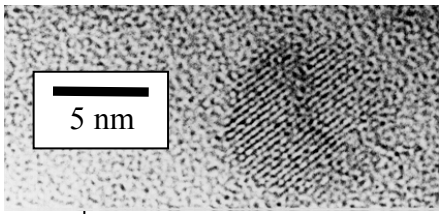
Part II: Photonic Crystals

Electromagnetic effects in periodic media
Media with periodicity in 1, 2, and 3-dimensions
Applications: Omni-directional reflection, sharp waveguide bends,
Light localization, Superprism effects, Photonic crystal fibers

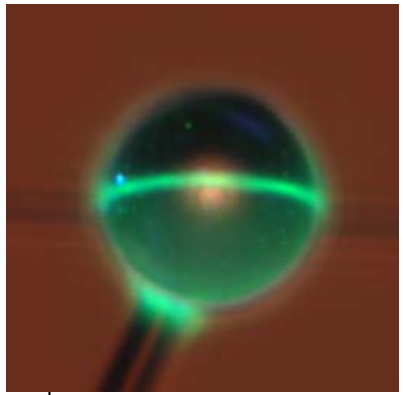
Part III: Metal optics (plasmonics) and nanophotonics

Light interaction with 0, 1, and 2 dimensional metallic nanostructures
Guiding and focusing light to nanoscale (below the diffraction limit)
Near-field optical microscopy
Transmission through subwavelength apertures
Metamaterials, optical magnetism, and negative refractive index
Perfect lens
Cloaking objects

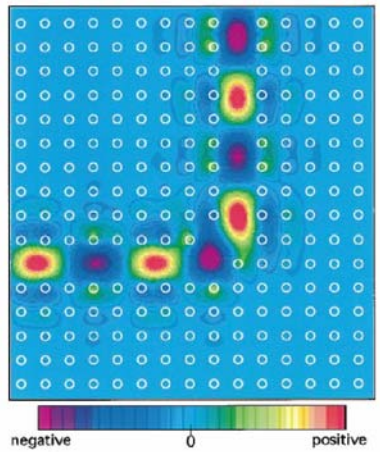
Overview in Images



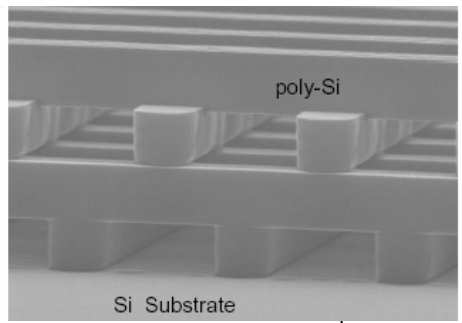
K.S. Min et al. PhD Thesis



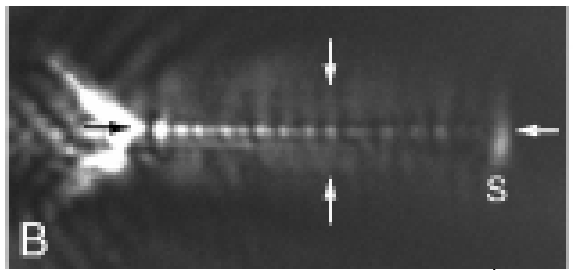
K.V. Vahala et al, Phys. Rev. Lett, 85, p.74 (2000)



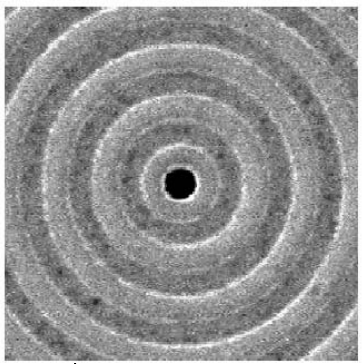
J. D. Joannopoulos, et al, Nature, vol.386, p.143-9 (1997)



S. Lin et al, Nature, vol. 394, p. 251-3, (1998)



J.R. Krenn et al., Europhys.Lett. **60, 663-669** (2002)



T.Thio et al., Optics Letters **26,** 1972-1974 (2001).

Motivation

Major breakthroughs are often materials related

- Stone Age, Iron Age, Si Age,….metamaterials
- People realized the utility of naturally occurring materials
- Scientists are now able to engineer new functional nanostructured materials

Is it possible to engineer new materials with useful optical properties

- Yes ! 

- Wonderful things happen when structural dimensions are ≈ λ_{light} and much less

This course talks about what these "things" are…and why they happen

What are the smallest possible devices with optical functionality ?

- Scientists have gone from big lenses, to optical fibers, to photonic crystals, to…
- Does the diffraction set a fundamental limit ?
- Possible solution: metal optics/plasmonics

Designing New Functional Devices

We need to be able to solve the following problem: