Intersectional Symposium Artificial Optical Materials (SYOM)

lead by the Semiconductor Physics Division (HL)

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The past years have witnessed tremendous progress in micro- and nano-fabrication techniques and corresponding developments in modern spectroscopic tools and methods. In parallel, the theoretical description of wave propagation and light-matter interaction in complex photonic systems has seen comparable advances. Taken together, these elements provide a robust and mature platform that may be called Artificial Optical Materials which stretches across many disciplines such as physics, material science, and chemistry. Within physics, there are several sub- disciplines such as semiconductor physics, surface science, and quantum optics and photonics where artificial optical materials already play a prominent role and will become even more important in the future. It is the purpose of this symposium to summarize the current state-of-the-art in the quickly developing field of artificial optical materials and to discuss future directions from various viewpoints.

Overview of Invited Talks and Sessions

(lecture room HSZ 01)

Invited Talks

SYOM 1.1	Mon	14:30–15:00	HSZ 01	**Photonic Metamaterials and Transformation Optics: Recent Progress** — •Martin Wegener
SYOM 1.2	Mon	15:00–15:30	HSZ 01	**Keeping a tight focus on matter** — •Philip St. J. Russell
SYOM 1.3	Mon	15:30–16:00	HSZ 01	**The Physics of Photonic Crystals LEDs** — •Claude Weisbuch, Elison Matioli
SYOM 1.4	Mon	16:15–16:45	HSZ 01	**Using nanophotonic structures to overcome conventional limits in solar energy conversion** — •Shanhui Fan
SYOM 1.5	Mon	16:45–17:15	HSZ 01	**Plasmonic nanocavities: New design concepts and determination of the complete mode spectrum using electron-beam spectroscopies** — •Stefan A. Maier

Sessions

SYOM 1.1–1.5	Mon	14:30–17:15	HSZ 01	**Artificial Optical Materials**

SYOM 1: Artificial Optical Materials

Time: Monday 14:30–17:15 Location: HSZ 01

Invited Talk SYOM 1.1 Mon 14:30 HSZ 01
Photonic Metamaterials and Transformation Optics: Recent Progress — •Martin Wegener — Karlsruhe Institute of Technology (KIT), DFG-Center for Functional Nanostructures (CFN), 76128 Karlsruhe, Germany

Metamaterials are artificial materials composed of sub-wavelength building blocks that are densely packed into an effective material. This concept allows for achieving effective optical properties that are not accessible in natural substance. In 2007, negative-index metamaterials have reached visible operation frequencies. Today, taking advantage of progress in three-dimensional nanofabrication, photonic metamaterials have even become truly three-dimensional. However, the reduction of metal losses still poses a major challenge. In this talk, I will start with a brief overview and then emphasize recent results of our group such as, e.g., (i) adding semiconductor quantum well gain and (ii) designing/fabricating/characterizing three-dimensional invisibility cloaking structures operating at visible frequencies. The latter has only become possible by using diffraction-unlimited optical lithography in three dimensions - the counterpart of STED fluorescence microscopy.

Invited Talk SYOM 1.2 Mon 15:00 HSZ 01
Keeping a tight focus on matter — •Philip St. J. Russell — Max-Planck Institute for the Science of Light, Guenther-Scharowsky Strasse 1/24, 91058 Erlangen, Germany

Photonic crystal fibres uniquely permit laser light to be kept tightly focused in a hollow micron-sized channel over propagation lengths of hundreds of metres. Recent experiments show how this can be used to enhance nonlinear light-matter interactions in gases and to trap and propel small particles using light.

Invited Talk SYOM 1.3 Mon 15:30 HSZ 01
The Physics of Photonic Crystals LEDs — •Claude Weisbuch[1,2] and Elison Matioli[1] — [1]Laboratoire de Physique de la Matière Condensée, CNRS, Ecole Polytechnique, Palaiseau, France — [2]Materials Department, UCSB, Santa Barbara, CA, USA

Photonic crystal (PhC) based Light Emitting Diodes (LEDs) display a rare blend of fundamental and applied concepts in solid state and semiconductor physics. Their remarkable properties rely on a mix of intrinsic materials properties and of electromagnetic properties of the PhC. Detailed understanding of PhC LED concepts can be obtained from studies of physics in and of devices.

Coffee Break

Invited Talk SYOM 1.4 Mon 16:15 HSZ 01
Using nanophotonic structures to overcome conventional limits in solar energy conversion — •Shanhui Fan — Ginzton Laboratory, Department of Electrical Engineering, Stanford University, Stanford, California 94305, U.S.A.

The use of nanophotonic structures drastically alter the nature of light-matter interactions, and opens new opportunities for overcoming some of the conventional limits in solar energy conversion. In this talk, we show that broad-band nanoscale modal confinement can be used to achieve light trapping efficiencies that are far beyond the Yablonovitch limit. We also discuss some of our recent works on solar bandwidth compression, with the ultimate aim of overcoming the Shockley-Queisser limit using only single-junction solar cells.

Invited Talk SYOM 1.5 Mon 16:45 HSZ 01
Plasmonic nanocavities: New design concepts and determination of the complete mode spectrum using electron-beam spectroscopies — •Stefan A. Maier — The Blackett Laboratory, Department of Physics, Imperial College London, London SW7 2AZ, United Kingdom

New design concepts such as the exploitation of dark modes, Fano resonances, and transformation optics allow for the design of plasmonic nanocavities with fascinating spectral properties, such as broadband superfocusing and invisibility dips, while at the same time retaining the deep sub-wavelength mode volume. A variety of cavity designs will be discussed, for applications ranging from optical sensing to photovoltaics. Furthermore, it will be shown that electron energy loss spectroscopy is an ideal tool for the determination and imaging of the mode spectrum of complex plasmonic cavities, including the elusive dark modes.