

# SYMPOSIUM ED10

Material Platforms for Plasmonics and Metamaterials—Novel Approaches Towards Practical Applications  
April 18 - April 21, 2017

## Symposium Organizers

Viktoriia Babicheva, Georgia State University  
Alexandra Boltasseva, Purdue University  
Harald Giessen, University of Stuttgart  
Pavel Ginzburg, Tel Aviv University

## Symposium Support

Neaspec GmbH  
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## Proceedings Statement

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\* Invited Paper

## TUTORIAL

### Plasmonics and Metamaterials for Active Photonics Devices

Monday Morning, April 17, 2017  
8:30 AM – 5:00 PM  
PCC North, 100 Level, Room 131 B

#### Part I: Mark Stockman

*Materials for Nanoplasmonics and Their Fundamental Properties*

The materials for nanoplasmonics include metals, in particular, alkaline, alkaline earth and transition metals (including noble metals such as silver, gold, and platinum), semi-metals such as graphene, semiconductors (highly-doped semiconductors used as plasmonic metals or lightly doped semiconductors used as gain media), topological insulators (whose surfaces can exhibit plasmonic properties) and dielectrics. This part of the tutorial will deal with fundamental properties of the materials. Among those, we will concentrate on dispersion properties of the plasmonic materials defined by fundamental principle of causality. We will also compare metals with conducting semiconductors and graphene. Novel two-dimensional semiconductors such as transitional metal dichalcogenides will also be discussed.

#### Part II: Mark Stockman

*Spaser as Coherent Generator of Nanoplasmonic Fields and Light*

In this part of the tutorial we will concentrate on spasers and spaser-based lasers. A spaser is a plasmonic nanosystem containing a metal nanoparticle, which plays a role of the plasmonic resonator, and semiconductor gain shell. We will consider fundamental theory of the spaser, including both stationary (CW) operation and its ultrafast kinetics. We will review an extensive literature on various spasers demonstrated experimentally. We will outline fundamentals of applications of both nanospasers and lasing spasers.

#### Part III: Nicholas Kotov

*Chiral Nanostructures and Metamaterials*

This tutorial lecture will describe the (1) fundamental requirements, (2) practical rationale, and (3) methods of manufacturing of chiroplasmonic and chiroexcitonic nanostructures. Special attention will be given to mapping the future direction of translation of structural and optical properties of inorganic nanoscale structures to applications. They will be exemplified by polarization optics for telecommunication, bioanalytical applications, holographic imaging, and anti-counterfeit technologies.

#### Part IV: Mark Luitzen Brongersma

*From Metamaterials to Active Metadevices*

In this tutorial lecture, I will start with an intuitive introduction to the optical properties of metamaterials. I will then discuss the possibility of creating 2dimensional (2D) metamaterials from optically resonant nanoscale semiconductor and metallic building blocks. The resulting metafilms and metasurfaces are ideal building blocks for optoelectronic devices that are commonly constructed from layered metal and semiconductor films.

#### Instructors

Nicholas A. Kotov, University of Michigan  
Mark Luitzen Brongersma, Stanford University  
Mark Stockman, Georgia State University

#### SESSION ED10.1: Active and Tunable Materials

Session Chairs: Viktoriia Babicheva and Matthew Sheldon  
Tuesday Morning, April 18, 2017  
PCC North, 100 Level, Room 131 B

#### 10:30 AM ED10.1.01

**Continuous Beam Steering at 1500 nm with Gate-Tunable Conducting Oxide Reconfigurable Metasurfaces** Ghazaleh Kafaie Shirmanesh; California Institute of Technology, United States.

#### 10:45 AM \*ED10.1.02

**Ultrafast and Nonlinear Plasmonics with Alternative Material Platforms** Vladimir Shalaev; Purdue University, United States.

#### 11:15 AM \*ED10.1.03

**Electrically Tunable Antennas** Mark L. Brongersma; Stanford University, United States.

#### 11:45 AM ED10.1.04

**Spatiotemporal Light Control in Dielectric Metasurfaces for Ultrafast Laser Beam Steering** Amr Shalout; Stanford University, United States.

#### SESSION ED10.2: Optoelectronics and Hybrid Nanostructures

Session Chairs: Koray Aydin and Viktoriia Babicheva  
Tuesday Afternoon, April 18, 2017  
PCC North, 100 Level, Room 131 B

#### 1:30 PM \*ED10.2.01

**Nonlinear Optics with Metasurfaces—Integration with Semiconductor Heterostructures** Igal Brener<sup>1,2</sup>; <sup>1</sup>Sandia National Laboratories, United States; <sup>2</sup>Center for Integrated Nanotechnologies, United States.

#### 2:00 PM ED10.2.02

**Bimodal Phase-Matching in Nonlinear Photonic-Plasmonic Waveguides** Taiiki Hatakeyama; University of California, Berkeley, United States.

#### 2:15 PM \*ED10.2.03

**Surface Plasmon Enhanced Optoelectronics** Pierre Berini<sup>1,2,3</sup>; <sup>1</sup>University of Ottawa, Canada; <sup>2</sup>University of Ottawa, Canada; <sup>3</sup>University of Ottawa, Canada.

#### 2:45 PM ED10.2.04

**Hot Electron Enhanced Thermionic Emission (HEETE) Converters for All-Metal Optical Power Generation** Matthew Sheldon; Texas A&M University, United States.

#### 3:00 PM BREAK

SESSION ED10.3: Plasmonic Lasers  
Session Chairs: Viktoriia Babicheva and Mark Stockman  
Tuesday Afternoon, April 18, 2017  
PCC North, 100 Level, Room 131 B

**3:30 PM ED10.3.01**

**Organo-Lead Halide Perovskite Plasmonic Nanolaser** Yu-Jung Lu;  
California Institute of Technology, United States.

**3:45 PM \*ED10.3.02**

**Colloidal-Quantum-Dot Spasers and Plasmonic Amplifiers** David J. Norris;  
ETH Zurich, Switzerland.

**4:15 PM \*ED10.3.03**

**Multi-Modal Lasing from Plasmonic Superlattices** Teri W. Odom;  
Northwestern University, United States.

**4:45 PM ED10.3.04**

**Ultrafast Dynamics of Lattice Plasmon Nanocavities** Weijia Wang;  
Northwestern University, United States.

SESSION ED10.4: Poster Session I: Novel Materials—Nanostructures  
and Applications

Session Chairs: Viktoriia Babicheva and Pavel Ginzburg  
Tuesday Afternoon, April 18, 2017  
8:00 PM - 10:00 PM  
Sheraton, Third Level, Phoenix Ballroom

**ED10.4.01**

**Wideband Light Absorbers in the Visible by  $\text{Ge}_2\text{Sb}_2\text{Te}_5$  and Al Nanogratings** Weiling Dong; Singapore University of Technology and Design, Singapore.

**ED10.4.02**

**Refractory Plasmonic Absorber for Efficient CZTS Solar Cells** Omar A. Abdelraouf; The American University in Cairo, Egypt.

**ED10.4.03**

**Comparison of Different Phase-Change Materials for Mid-Infrared Antenna Resonance Frequency Tuning** Thomas Taubner; RWTH Aachen University, Germany.

**ED10.4.04**

**Ultrafast Mid-Infrared Modulator Based on Optically Controlled Graphene Metasurface** Ali Basiri; Arizona State University, United States.

**ED10.4.05**

**Scalable Energy-Tuned Plasmonic Nanoadditive Composites** Mark Griep;  
US Army Research Lab, United States.

SESSION ED10.5: Metasurfaces and Metamaterials  
Session Chairs: Viktoriia Babicheva and Kevin MacDonald

Wednesday Morning, April 19, 2017  
PCC North, 100 Level, Room 131 B

**8:00 AM ED10.5.01**

**Gapless States in Microwave Artificial Graphene** Yulia Dautova; University of Exeter, United Kingdom.

**8:15 AM \*ED10.5.02**

**Absorbers in the Flatland—From Plasmonic Metasurfaces to 2D Materials** Koray Aydin; Northwestern University, United States.

**8:45 AM \*ED10.5.03**

**Recent Progress in Dielectric Metasurfaces** Uriel Levy; Hebrew University of Jerusalem, Israel.

**9:15 AM \*ED10.5.04**

**Metamaterials for Nonlinear Optics** Anatoly Zayats; King's College London, United Kingdom.

**9:45 AM BREAK**

SESSION ED10.6: Light Control with Graphene  
Session Chairs: Pavel Ginzburg and Jon Schuller  
Wednesday Morning, April 19, 2017  
PCC North, 100 Level, Room 131 B

**10:15 AM ED10.6.01**

**First Demonstration of Phase Tuning from a Mid-IR Graphene-Gold Metasurface Greater than 200 Degrees** Philip Hon<sup>1,3</sup>; <sup>1</sup>Northrop Grumman Corporation, NG Next, United States; <sup>3</sup>California Institute of Technology, United States.

**10:30 AM ED10.6.02**

**Graphene-Coated Metasurface as a Tunable SERS Platform** Vrinda Thareja; Stanford University, United States.

**10:45 AM \*ED10.6.03**

**Sculpting Nanosecond Laser Pulses In-Flight Using Graphene-integrated Metasurface** Gennady Shvets; The University of Texas at Austin, United States.

**11:15 AM \*ED10.6.04**

**Probing Quantum Phenomena in Graphene by Infrared Nano-Imaging of Plasmonic Waves** Dmitri Basov; Columbia University, United States.

**11:45 AM ED10.6.05**

**Full Phase Control of Light Using Graphene Plasmons** Achim Woessner; The Institute of Photonic Sciences (ICFO), Spain.

SESSION ED10.7: Switchable Materials  
Session Chairs: Pavel Ginzburg and Uriel Levy  
Wednesday Afternoon, April 19, 2017  
PCC North, 100 Level, Room 131 B

**1:30 PM ED10.7.01**

**Dynamic Thermo-Optic Tuning of Infrared PbTe Mie Resonators** Jon A. Schuller; University of California, Santa Barbara, United States.

**1:45 PM \*ED10.7.02**

**All-Chalcogenide Plasmonic and Dielectric Phase-Change Metadevices** Nikolay I. Zheludev<sup>1,2</sup>; <sup>1</sup>University of Southampton, United Kingdom; <sup>2</sup>Nanyang Technological University, Singapore.

**2:15 PM ED10.7.03**

**Active Metadevices on Optical Fiber Platforms** Kevin F. MacDonald; University of Southampton, United Kingdom.

**2:30 PM BREAK**

**3:30 PM ED10.7.04**

**Reversible Switching of Highly Confined Phonon-Polaritons with an Ultrathin Phase-Change Material** Thomas Taubner; RWTH Aachen University, Germany.

**3:45 PM \*ED10.7.05**

**Reconfigurable Metasurfaces Using Phase Change Materials** Jacob Scheuer; Tel-Aviv University, Israel.

**4:15 PM \*ED10.7.06**

**Approaches towards Actively Tunable Mid- to Far-Infrared Nanophotonics** Joshua D. Caldwell; U.S. Naval Research Laboratory, United States.

**4:45 PM ED10.7.07**

**Phase Change Metamaterial Pollution Sensor** Weiling Dong; Singapore University of Technology and Design, Singapore.

SESSION ED10.8: Poster Session II: Novel Materials and Phenomena  
Session Chairs: Viktoriia Babicheva and Pavel Ginzburg  
Wednesday Afternoon, April 19, 2017  
8:00 PM - 10:00 PM  
Sheraton, Third Level, Phoenix Ballroom

**ED10.8.01**

**Counterintuitive Optical Properties of Infrared-Plasmonic Oxide Superlattices by Atomic Layer Deposition** [Do-Joong Lee](#); Brown University, United States.

**ED10.8.02**

**Plasmon to Exciton Energy Conversion in a Single Nanoparticle** [Natalia Kholmicheva](#); Bowling Green State University, United States.

**ED10.8.03**

**Measuring of the Energy Transfer Efficiency between Plasmon Nanoparticles and Quantum Dots Using Sample-Transmitted Excitation Photoluminescence (STEP)** [Pavel Moroz](#); Bowling Green State University, United States.

**ED10.8.04**

**Scalable Physical Coloration Based on Plasmonic Nanostructures** [Tianyi Shen](#); Brown University, United States.

**ED10.8.05**

**Purcell-Like Effect for Actively Controlled Resonant Semiconductor Nanostructures** [Aaron Holsteen](#); Stanford University, United States.

SESSION ED10.9: Energy Harvesting and Sensing Applications  
Session Chairs: Viktoriia Babicheva and Pavel Ginzburg  
Thursday Morning, April 20, 2017  
PCC North, 100 Level, Room 131 B

**8:00 AM ED10.9.01**

**Metasurface Back Reflectors for External Control over Semiconductor Nanowire Resonances** [Jorik Van de Groep](#); Stanford University, United States.

**8:15 AM ED10.9.02**

**Nanogrid Made Invisible by Texture for Thin Film Solar Cells** [Joop van Deelen](#); TNO, Netherlands.

**8:30 AM ED10.9.03**

**Suppression of Infrared Absorption in Nanostructured Metals by Controlling Faraday Inductance and Electron Path Length** [Sang Eon Han](#)<sup>1,2</sup>; <sup>1</sup>University of New Mexico, United States; <sup>2</sup>University of New Mexico, United States.

**8:45 AM \*ED10.9.04**

**Complete Control over Reflected Fields with Gap Surface Plasmons** [Fei Ding](#); University of Southern Denmark, Denmark.

**9:15 AM \*ED10.9.05**

**Dielectric and Plasmonic Platforms for Surface-Enhanced Sensing, Nanochemistry and Nonlinear Optics** [Stefan A. Maier](#); Imperial College London, United Kingdom.

**9:45 AM ED10.9.06**

**CMOS-Compatible Integrated Surface Enhanced Raman Scattering Sensors** [Cuong Nguyen](#); University of California, Irvine, United States.

**10:00 AM BREAK**

**10:15 AM ED10.9.07**

**A Piezoplasmonic Response in Metal Nanoislands—Optical Sensing of Strain in Biological Environments Using Low-Dimensional Metamaterials** [Brandon C. Marin](#); University of California, San Diego, United States.

**10:30 AM \*ED10.9.08**

**Aluminum Plasmonics—New Wavelengths and New Versatility for Sensing Applications** [Naomi J. Halas](#); Rice University, United States.

**11:00 AM ED10.9.09**

**Interdigitated Periodic Plasmonic Nanostructures for Electrochemical SERS Observation of Biomolecule Redox Dynamics** [Dvin Adalian](#); California Institute of Technology, United States.

**11:15 AM ED10.9.10**

**Laser Processing of Low Optical Reflection Micro/Nano-Patterned Si Substrates for SERS** [Rupali Das](#); Indian Institute of Technology Delhi, India.

**11:30 AM \*ED10.9.11**

**Control of Light-Matter Interactions with Nonlocal Dielectric Environments** [Mikhail Noginov](#); Norfolk State University, United States.

SESSION ED10.10: Plasmonics and Metamaterials Applications  
Session Chairs: Viktoriia Babicheva and Wenshan Cai  
Thursday Afternoon, April 20, 2017  
PCC North, 100 Level, Room 131 B

**1:30 PM ED10.10.01**

**Plasmonic Transition Metal Nitrides for Harsh-Environment Applications** [Urcan Guler](#); Purdue University, United States.

**1:45 PM ED10.10.02**

**Temperature and Phase Transition Sensing in Liquids with Fluorescent Probes** [Pavel Ginzburg](#)<sup>1,2</sup>; <sup>1</sup>Tel Aviv University, Israel; <sup>2</sup>ITMO, Russian Federation.

**2:00 PM ED10.10.03**

**Scalably Manufactured Metamaterial for Effective Day-Time Radiative Cooling** [Yao Zhai](#); University of Colorado Boulder, United States.

**2:15 PM ED10.10.04**

**Metaplatforms for Analog Computing** [Brian Edwards](#); University of Pennsylvania, United States.

**2:30 PM ED10.10.05**

**Polarization-Resolved Spectroscopy Using Multiresonant Plasmonic Bull's-Eye Antennas** [Eva De Leo](#); ETH Zurich, Switzerland.

**2:45 PM BREAK**

SESSION ED10.11: Optical Phenomena in Metasurfaces and Nanostructures  
Session Chairs: Yohannes Abate and Pavel Ginzburg  
Thursday Afternoon, April 20, 2017  
PCC North, 100 Level, Room 131 B

**3:15 PM ED10.11.01**

**Ultra-Light Subwavelength-Thickness Emissive Metaphotonic Structures for Thermal Radiation Management** [Ali Naqavi](#); California Institute of Technology, United States.

**3:30 PM ED10.11.02**

**Silicon Nanoantennas for Highly Directional Light Emission from Monolayer MoS<sub>2</sub>** [Ahmet Fatih Cihan](#); Stanford University, United States.

**3:45 PM \*ED10.11.03**

**Magnetic Resonant Effects in High-Index Dielectric Nanostructures and Metasurfaces** [Arseniy Kuznetsov](#); Data Storage Institute, Singapore.

**4:15 PM \*ED10.11.04**

**Nanoimaging of IR and THz Polaritons in 2D Materials** [Rainer Hillenbrand](#); CIC nanoGUNE, Spain.

**4:45 PM ED10.11.05**

**Near-Field Edge Fringes in Nanolayer Materials** [Viktoriia Babicheva](#); Georgia State University, United States.

SESSION ED10.12: Poster Session III: Plasmonic Materials for Sensing  
Thursday Afternoon, April 20, 2017  
8:00 PM - 10:00 PM  
Sheraton, Third Level, Phoenix Ballroom

**ED10.12.01**

**Plasmonic Nanoantennas with Vertically Coupled Anisotropic Complementary Structures for Dual-Mode Infrared Molecule Sensing** Xiahui Chen<sup>1,2</sup>; <sup>1</sup>Arizona State University, United States; <sup>2</sup>Arizona State University, United States.

**ED10.12.02**

**Dual-Resonant Perfect Absorber for Detecting Multiple Molecular Fingerprints** Habibe Durmaz<sup>1,2</sup>; <sup>1</sup>Boston University, United States; <sup>2</sup>Recep Tayyip Erdogan University, Turkey.

**ED10.12.03**

**Nitride-Based Surface Plasmon Resonance Biosensors** Kun-Yu Lai; National Central University, Taiwan.

**ED10.12.04**

**Electrokinetic-Manipulation Integrated Plasmonic-Photonic Hybrid Raman Nanosensors with Dual Enhanced Sensitivity** Chao Liu; The University of Texas at Austin, United States.

**ED10.12.05**

**Optical Contribution of Graphene in Enhanced Sensitivity of Graphene-Gold Coupled Surface Plasmon Resonance Sensing** Kyungwha Chung; Ewha Womans University, Korea (the Republic of).

SESSION ED10.13: Novel Plasmonic Materials and Metamaterials  
Session Chairs: Pavel Ginzburg and Arseniy Kuznetsov  
Friday Morning, April 21, 2017  
PCC North, 100 Level, Room 131 B

**8:15 AM ED10.13.01**

**Metal Germanides for Mid- and Long-Wave Infrared Plasmonics** Evan M. Smith<sup>1,2</sup>; <sup>1</sup>Air Force Research Laboratory, United States; <sup>2</sup>KBRwyle Laboratories, United States.

**8:30 AM \*ED10.13.02**

**New Materials for Infrared and Active Plasmonics** Otto L. Muskens; University of Southampton, United Kingdom.

**9:00 AM ED10.13.03**

**High-Performance Doped Silver Films—Overcoming Fundamental Material Limits for Nanophotonic Applications** Cheng Zhang<sup>1,2</sup>; <sup>1</sup>University of Michigan—Ann Arbor, United States; <sup>2</sup>National Institute of Standards and Technology, United States.

**9:15 AM ED10.13.04**

**Doped Cadmium Oxide Thin Films Provide a Broadly Tunable, Low-Loss and Scalable Plasmonic Material Platform** Evan L. Runnerstrom; North Carolina State University, United States.

**9:30 AM \*ED10.13.05**

**Plasmonic Metamaterials as a Self-Contained Platform for Optoelectronic Signal Processing** Wenshan Cai; Georgia Institute of Technology, United States.

**10:00 AM BREAK**

**10:30 AM \*ED10.13.06**

**Beyond Graphene Plasmonics** Tony Low; University of Minnesota, United States.

**11:00 AM \*ED10.13.07**

**Nanoscopy of Black Phosphorus** Yohannes Abate; Georgia State University, United States.

**11:30 AM ED10.13.08**

**Impedance Spectroscopy Characterization of Colloidal Indium Tin Oxide Films and Related Materials** Rosario Gerhard; Georgia Institute of Technology, United States.

**11:45 AM ED10.13.09**

**Extracting Dielectric Function of Plasmonic Metal Oxide Using Synchrotron-Based Infrared Nano-Spectroscopy (SINS) on Single Nanocrystal Scale** Ankit Agrawal; The Univ. of Texas at Austin, United States.

SESSION ED10.14: Novel Fabrication Techniques  
Session Chairs: Pavel Ginzburg and Tony Low  
Friday Afternoon, April 21, 2017  
PCC North, 100 Level, Room 131 B

**1:30 PM ED10.14.01**

**Substrate Insensitive Plasmonic Titanium Nitride Film Deposited by Atomic Layer Deposition** Zu-Po Yang; National Chiao Tung University, Taiwan.

**1:45 PM ED10.14.02**

**Nonthermal Plasma-Synthesized Titanium Nitride Nanocrystals with Gold-Like Plasmonic Properties for Biological Applications** Katelyn S. Schramke; University of Minnesota, United States.

**2:00 PM ED10.14.03**

**Efficient Combination of Interference and Plasmon Resonance Raman Amplification by Optimized Heterostructures for Optical Microscopy and Molecule Detection** Alicia de Andres; ICMN- CSIC, Spain.

**2:15 PM ED10.14.04**

**Directed Nanopatterning of Self-Organized Bravais Lattices** Onur Tokel; Bilkent University, Turkey.

**2:30 PM ED10.14.05**

**Lithographically Patterned Plasmonic Au Nanotube Array for Solar Energy Harvesting** Hak-Jong Choi; Korea University, Korea (the Republic of).

**2:45 PM ED10.14.06**

**Nanoimprinted Self-Folding Mid-IR Tunable Metasurfaces** Vivek Nagal; Johns Hopkins University, United States.

**3:00 PM BREAK**

SESSION ED10.15: Self-Assembly Methods for Nanostructures and Metamaterials

Session Chairs: Pavel Ginzburg and Cheng Zhang  
Friday Afternoon, April 21, 2017  
PCC North, 100 Level, Room 131 B

**3:30 PM ED10.15.01**

**Mechanically-Assembled Meta-Materials Based on Atomically-Thin Crystals** Juyoung Leem; Univ. of Illinois at Urbana-Champaign, United States.

**3:45 PM ED10.15.02**

**Engineering Nanoscale Structures with Nanometer Precision and Surface Uniformity for Plasmonic Devices** Farnaz Niroui; Massachusetts Institute of Technology, United States.

**4:00 PM ED10.15.03**

**Engineering Disordered Metamaterials for Broadband High Optical Absorption** Sheldon Hewlett; Central Michigan University, United States.

**4:15 PM ED10.15.04**

**Block-Copolymer Based Self-Assembled Hyperbolic Metamaterials in the Visible Range** Xuan Wang; Centre de Recherche Paul Pascal-Université de Bordeaux, France.

**4:30 PM ED10.15.05**

**Dynamic Plasmonic Metamaterials with Broken Symmetry Created via Directed Self-Assembly** David B. Litt<sup>1,2</sup>; <sup>1</sup>Lawrence Berkeley National Laboratory, United States; <sup>2</sup>University of California, Berkeley, United States.

**4:45 PM ED10.15.06**

**Continuous Flow Colloidal Synthesis and Stabilization of Gold-Polystyrene Patchy Particles and their Thin Film Assembly into Layers with Particle-Anisotropy Dependent Optical Properties** Robin N. Klupp Taylor<sup>1,2,3</sup>; <sup>1</sup>Friedrich-Alexander-University of Erlangen-Nürnberg, Germany; <sup>2</sup>Friedrich-Alexander-University of Erlangen-Nürnberg, Germany; <sup>3</sup>Friedrich-Alexander-University of Erlangen-Nürnberg, Germany.