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14. ABSTRACT
Science and Applications of Nanolasers and Subwavelength Photonics Incubators were two separate meetings held in Washington, DC on 7-9 and 21-23 September 2016. The two Incubators provided unique and focused experiences and valuable opportunity to discuss advances, challenges and opportunities regarding the niche fields.

The Science and Applications of Nanolasers Incubator reviewed the original motivations for laser miniaturization and the current state of the art in nanolasers and discussed emerging dialogues in the literature concerning the

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Report Title

OSA Incubators: Science and Applications of Nanolasers; and Subwavelength Photonics

ABSTRACT

Science and Applications of Nanolasers and Subwavelength Photonics Incubators were two separate meetings held in Washington, DC on 7-9 and 21-23 September 2016. The two Incubators provided unique and focused experiences and valuable opportunity to discuss advances, challenges and opportunities regarding the niche fields.

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The Subwavelength Photonics Incubator focused on controlling flow of light in optical materials structured at sub- wavelength scale, i.e. with structural dimensions smaller than the wavelength of light. The program aimed to establish new directions for the development of the emerging photonics structures and search for new applications that would be enabled by these structures.

The two meetings convened a total of 60 attendees and featured invited talks, panels and moderated group discussions.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received	Book Chapter

TOTAL:

Patents Submitted

N/A

Patents Awarded

N/A

Awards

N/A

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

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Scientific Progress

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FINAL PROGRESS REPORT (FPR)

2016 OSA Incubators: Science and Applications of Nanolasers; and Subwavelength Photonics

Report Submitted to:

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P.O. Box 12211
Research Triangle Park, NC 27709-2211

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Optical Society of America
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FOREWORD

The Optical Society of America (OSA) greatly appreciates the grant in the amount of $10,000 from Army Research Office (ARO) for the support of two OSA Incubators: Science and Applications of Nanolasers; and Subwavelength Photonics, which were held in Washington, DC on 7-9 and 21-23 September 2016.

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Appendix A. Science and Applications of Nanolasers Incubator Program Book

Appendix B. Subwavelength Photonics Incubator Program Book

DISTRIBUTION STATEMENT

DISTRIBUTION A. Approved for public release: distribution unlimited.

ABSTRACT

Science and Applications of Nanolasers and Subwavelength Photonics Incubators were two separate meetings held in Washington, DC on 7-9 and 21-23 September 2016. The two Incubators provided unique and focused experiences and valuable opportunity to discuss advances, challenges and opportunities regarding the niche fields.

The Science and Applications of Nanolasers Incubator reviewed the original motivations for laser miniaturization and the current start of the art in nanolasers and discussed emerging dialogues in the literature concerning the application of small lasers. The goal of the program was to forge connections between the diverse communities working on different approaches to nanolasers in order to identify fundamental goals and limits, potential applications for and roadmap for nanolaser research that can bring the science closer to commercialization

The Subwavelength Photonics Incubator focused on controlling flow of light in optical materials structured at sub- wavelength scale, i.e. with structural dimensions smaller than the wavelength of light. The program aimed to establish new directions for the development of the emerging photonics structures and search for new applications that would be enabled by these structures.

The two meetings convened a total of 60 attendees and featured invited talks, panels and moderated group discussions.

GOALS AND OBJECTIVES

For the Science and Applications of Nanolasers Incubator:

- Forge connections between the diverse communities working on different approaches to nanolasers in order to identify fundamental goals and limits, potential applications for and roadmap for nanolaser research that can bring the science closer to commercialization.

For the Subwavelength Photonics Incubator:

- Establish new directions for the development of the emerging photonics structures and search for new applications that would be enabled by these structures within the Subwavelength Photonics Incubator.

For both Incubators:

- Provide unique and focused experiences and valuable opportunity to meet and discuss advances, challenges and opportunities regarding the niche fields.
- Target emerging topics and fields that do not have the critical mass needed to support an OSA topical meeting structure.

- Function to further the interest and support of promising topic areas, assessing the broader implications of the topic for future research and application.
- Explore possibilities for greater inclusion and propagation of the topic into peer-reviewed topical meeting and/or congresses or conferences.
- Encourage extensive formal and informal discussion while establishing a sense of community among participants.
- Offer a valuable means of disseminating information and ideas in a way that cannot be achieved through the usual channels of communication—publications and presentations at large scientific meetings.

ACCOMPLISHMENTS

OSA worked with the Incubator hosts to conduct two meetings:

Science and Applications of Nanolasers Incubator Scope and Featured Topics
7-9 September 2016, Washington, DC, USA
Organizers:
Volker Sorger, GeorgeWashington University, USA
Rupert Oulton, Imperial College London, United Kingdom
Ren-MinMa, Peking University, China

The science of semiconductor lasers with wavelength scale dimensions or less has emerged as a prominent research area in the past 15 years. There are many diverse approaches to achieving the necessary control over light needed to make semiconductor nanolasers, e.g. nanowires, photonic crystals, and metals; however, the communities involved typically have very little overlap. They are nonetheless united by the goal to make the smallest light emitting devices possible. Originally motivated by the promise of reducing thresholds and eliciting ultrafast responses, as the size of lasers has reduced below the vacuum wavelength electrical injection has become significantly harder. Even in cases where the requisite electronic and optical control has been satisfied simultaneously, parasitic loss and heat dissipation have emerged as new limitations. This Incubator reviewed the original motivations for laser miniaturization and the current start of the art in nanolasers and discussed emerging dialogues in the literature concerning the application of small lasers. Key questions that were explored throughout the program included:

- Are there definable and defendable benefits of constructing ever smaller lasers and light sources?
- What are fundamental scaling laws of light sources?
- Exactly how small should a lasers device be given technological desired functionality?
- If lasers should be smaller than VCSELs, which are the smallest commercially relevant laser available, then what will be the applications that could be enabled by these new class of light sources?

Subwavelength Photonics Incubator Scope and Featured Topics
21-23 September 2016, Washington, DC, USA
Organizers:
Pavel Cheben, National Research Council of Canada
Inigo Molina Fernandez, University of Malaga, Spain
David Smith, Duke University, USA
Weidong Zhou, University of Texas at Arlington, USA

The Subwavelength Photonics Incubator focused on controlling flow of light in optical materials structured at sub- wavelength scale, i.e. with structural dimensions smaller than the wavelength of light. Much of exciting progress has been made in this area, including subwavelength index engineering in integrated optics, optical metamaterials, index and dispersion engineered silicon photonic devices, plasmonic devices, high-index-contrast gratings, anti-reflecting structures, resonant and holographic metasurfaces, nanostructured solar cells, ultra-thin lenses and nanophotonic couplers, to name a few. The Incubator's goal was to establish new directions for the development of these emerging photonics structures and search for new applications that would be enabled by these structures. Key challenges in the field were addressed and new solutions to overcome the present limits were presented, including:

- Exploiting subwavelength structures for photonics and integrated optics. Subwavelength structured effective media and metamaterials.
- Subwavelength refractive index and dispersion engineering in waveguide optics.
- Subwavelength patterning of optical surfaces. Antireflective gratings.
- High-index-contrast gratings and metastructures.
- Subwavelength grating and metamaterials for silicon photonics and plasmonics.
- Subwavelength engineered nanophotonic structures for photonic integrated circuits.
- Resonant and holographic optical metasurfaces. Broadband achromatic metasurfaces, collimators and lenses.
- Nanostructured solar cells.
- Nano-materials synthesis, processing, and integration and more.

Significant Results

1. 25 individuals attended the Science and Applications of Nanolasers Incubator.
2. 35 individuals attended the Subwavelength Photonics Incubator.
3. Participants included individuals from academia, government agencies and industry. There were also nine (9) countries represented.
4. Each program included invited talks, panels and moderated discussion time. See appendix for detailed agendas.
5. OSA provided the staffing and support for the planning and execution of the program throughout the whole performance period. Additional funds were sought to help lower the participation costs for all attendees to ensure that deserving individuals in need of assistance were able to attend.

Program Information and Next Steps

The Incubators exposed participants to in-depth learning of nanolasers and their applications as well as subwavelength photonics from internationally recognized academic and industry leaders in the field. The programs consisted of lectures, networking events and discussion time. The programs were designed to maximize formal and informal discussions and provide networking time for the participants. See the complete agendas in the Appendix.

OSA also facilitates the continued networking of the group through maintaining a shared drive participants have access to in order to share information and next steps. By means of the OSA website, the OSA member magazine, the OSA journals, and other means as necessary and appropriate, the Incubators' staff work with the Hosts, sponsors and participants of the Incubator to further publicize and continue the work of the Incubator topic. This may include other outcomes such as a special issue journal, a whitepaper, or a follow-up meeting.

ARO GRANT FUNDS

The ARO funds received from this grant were used to reduce the overall registration costs for all attendees and to cover full local registration for four (4) students for the two Incubator programs. In addition, the grant supported program costs, including printing, materials and supplies, and equipment rental. The remaining funds were used to help offset program management costs. The Program Books with more specific information on topics and speakers are attached.

DISSEMINATION

Incubator meetings by design have lasting impact with great content dissemination. During the Incubator OSA published two blog posts for each meeting, and following the Incubator the outcomes are featured in an article in Optics & Photonics News (OPN), the OSA member magazine, extending the reach of the meeting. The January 2017 OPN issue featured the Science and Applications of Nanolasers meeting and the May 2017 issue will feature the Subwavelength Photonics Incubator.

The results were disseminated through:
OSA websites http://www.osa.org/en-us/meetings/incubator_meetings/nanolasersinc/, http://www.osa.org/en-us/meetings/incubator_meetings/osa_subwavelength_photonics_incubator/
OSA blog http://www.osa.org/en-us/the_optical_society_blog/2016/september_2016/

OSA INCUBATORS
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OSA Science & Applications of Nanolasers Incubator

7-9 September 2016
Washington, DC USA

Program Supported By:

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OSA Incubator on the Science & Application of Nanolasers

7-9 September 2016
George Washington University, Science & Engineering Building
Washington, DC

Hosts:
Volker Sorger, George Washington University, United States
Rupert Oulton, Imperial College London, United Kingdom
Ren-Min Ma, Peking University, China

Agenda

Wednesday, 7 September 2016

Afternoon	Arrival/Hotel Check-in *George Washington Inn Hotel* *824 New Hampshire Ave NW, Washington, DC*
18:00	Welcome Dinner *Grillfish, 1200 New Hampshire Ave NW, Washington, DC*

Thursday, 8 September 2016

8:30	Breakfast *George Washington University, Science & Engineering Building* *Lehman Auditorium, B 1270, 800 22nd St NW, Washington, DC*
9:00	Welcome *Can Korman, Assoc. Dean, SEAS, GWU*
9:05	Welcome *Chad Stark, OSA Foundation Executive Director*

PART 1: ORIGINAL MOTIVATIONS & THE STATE OF THE ART

Session 1.1: Why Small Light Sources?
Session 1.1 Chair: Rupert Oulton, Imperial College London, UK

9:15	Motivations for Small Lasers *Renmin Ma, Peking University, China* *Volker Sorger, George Washington University, USA* *Rupert Oulton, Imperial College London, UK*

9:15 Motivations for Small Lasers
Renmin Ma, Peking University, China
Volker Sorger, George Washington University, USA
Rupert Oulton, Imperial College London, UK

9.45 Keynote: Optical Antenna-Enhanced Nano-LED
Ming Wu, University of California, Berkeley, USA

10:30 Discussion
Rupert Oulton, Imperial College London, UK

11.00 Coffee Break

Session 1.2: Optical Confinement & Feedback in Nanolasers
Session 1.2 Chair: Ming Wu, UC Berkeley, USA

11:30 Plasmonic Lasers in Strong Coupling Environments
Mikhail Noginov, Norfolk State University, USA

11:50 Plasmonics Lasers
Cun-Zheng Ning, Arizona State University, USA

12:10 Coherence & Dynamics of Metal-clad Nanolasers
Si-Hui Athena Pan, University of California, San Diego, USA

12:30 Parity Time Symmetry Lasers
Mercedeh Khajavikhan, University of Central Florida, USA

12:50 Panel discussion
Moderator: Ming Wu, University of California, Berkeley, USA
Session 1.2 speakers

13:30 Lunch, provided

Session 1.3: Nano-Cavities & the Purcell Effect
Session 1.3 Chair: Jacob Khurgin, Johns Hopkins University, USA

15:00 Nano-Cavities & Purcell Effect
Maiken Mikkelsen, Duke University, USA

15:20 Purcell Effect in Hybrid Plasmonic Nanowires and Cavity Scaling Laws
Volker Sorger, George Washington University, USA

Thursday, 8 September 2016, continued

15:20 Purcell Effect in Hybrid Plasmonic Nanowires and Cavity Scaling Laws
Volker Sorger, George Washington University, USA

15:40 Engineering Light-matter Interactions for Novel Nanophotonics
Ritesh Agarwal, University of Pennsylvania, USA

16:00 Panel Discussion
Moderator: Jacob Khurgin, Johns Hopkins University, USA
Session 1.3 speakers

16:30 Coffee Break

Session 1.4: Nano-Laser Arrays
Session 1.4 Chair: Ritesh Agarwal, University of Pennsylvania, USA

17.00 Nanoplasmonic Array Lasers
Vladamir Shalalev, Purdue University, USA

17:20 Bound State in the Continuum Nanophotonic Cavities & Lasers
Boubacar Kante, UC San Diego, USA

17:40 Lasing from Plasmonic Nanocavity Arrays
Danqing Wang, North Western University, USA

18:00 Panel Discussion
Moderator: Ritesh Agarwal, University of Pennsylvania, USA
Session 1.4 speakers

18:30 Networking Dinner
RIS, 2275 L St NW, Washington, DC

Friday, 9 September 2016

8:30 Breakfast
George Washington University, USA

PART 2: APPLICATIONS & FUTURE RESEARCH DIRECTIONS

Session 2.1: Exploiting Near-Field Effects
Session 2.1 Chair: Cun-Zheng Ning, Arizona State University, USA

9:00 Sensing with Nanolasers
Renmin Ma, Peking University, China

9:20 Plasmomechanical Absorption for Phonon Lasing
Ertugrul Cubukcu, UC San Diego, USA

9:40 Nanofocusing Nanolaser
Rupert Oulton, Imperial College London, UK

10:00 Panel Discussion
Moderator: Cun-Zheng Ning, Arizona State University, USA
Session 2.1 speakers

10:30 Coffee Break

Session 2.2: Reassessing Our Motivation for Small Lasers
Session 2.2 Chair: Josh Conway, DARPA, USA

11:00 Industry Perspective: III-V integrated Nanolasers
Ning Li, IBM, USA

11:20 Electrically Pumped III-Nitride Nanowire Lasers
Zetian Mi, McGill University, Canada

11:40 The Problem with Nanolasers
Jacob Khurgin, Johns Hopkins University, USA

12:00 Panel Discussion
Moderator: Josh Conway, DARPA, USA

12:30 *Wrap-up Discussion*
Hosts: Session 2.2 Speakers
Renmin Ma, Peking University, China
Volker Sorger, George Washington University, USA
Rupert Oulton, Imperial College London, UK

12:45 Lunch, provided

13:30 Adjourn

OSA Science & Applications of Nanolasers Incubator				
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OSA Science & Applications of Nanolasers Incubators

PARTICIPANT BIOGRAPHIES

Ritesh Agarwal

Ritesh Agarwal is a Professor in the Department of Materials Science and Engineering at the University of Pennsylvania. He earned his undergraduate degree from the Indian Institute of Technology, Kanpur in 1996, and a master's degree from the University of Chicago. He received his Ph.D. in physical chemistry from University of California at Berkeley in 2001 researching liquid and protein solvation and photosynthesis via nonlinear optical techniques. After completing his Ph.D. , Ritesh was a postdoctoral fellow at Harvard where he studied the photonic properties of semiconductor nanowires. His current research interests include structural, chemical, optical and electronic properties of low-dimensional systems. Some of his key research accomplishments include nanowire injection lasers (Nature, 2003), nanowire phase change memory (Nature Nano, 2007; Science, 2012, Nature Communications, 2016), large Purcell enhancements in plasmonic nanocavities (Nature Materials, 2011; Nature Photonics, 2013), all optical switching in nanowires (Nature Nano, 2012), photon spin dependent photocurrents in Silicon (Science, 2015), and optics of 2D excitonic materials (Nature Comm, 2015; Nano Letters, 2016). Ritesh is the recipient of the NSF CAREER award in 2007, NIH Director's New Innovator Award in 2010 and the SPIE Nanoengineering Pioneer Award in 2014.

Josh Conway

Dr. Josh Conway joined DARPA in August 2012 as a program manager for the Microsystems Technology Office. His interests include linear and non-linear nano-photonics from UV to LWIR frequencies, active integrated photonic devices, RF photonics, advanced imaging systems and revolutionary space systems. Dr. Conway came to DARPA from Kinsey Technical Services (KTSi) where he was senior principal engineer of special programs at the Los Angeles Air Force Base. Prior to joining KTSi, Dr. Conway joined the technical staff of The Aerospace Corporation in 2003. There he performed basic research on RF photonic systems and led research in electrically-driven, sub-wavelength light sources. Dr. Conway also worked as Boeing Satellite Systems starting in 2001 where he designed, built and tested fiber-optic subsystems for inter-satellite laser communication systems. Dr. Conway has received numerous awards, has authored more than 30 technical papers and conference proceedings and holds nine patents. Dr. Conway received a Bachelor of Science in Physics and Master of Science in Electrical Engineering from University of Illinois in Urbana, Illinois. He earned his Doctor of Philosophy in Electrical Engineering from University of California in Los Angeles for research in optical structures able to efficiently couple to deeply sub-wavelength dimensions

Ertugrul Cubukcu

Professor Ertugrul Cubukcu's research involves engineering light matter interactions on the nanoscale for achieving novel functionality in optical devices and sensors for application in medical diagnostics and environmental monitoring. He also investigates the potential of

emerging two-dimensional semiconducting and semimetallic materials (i.e. graphene) for photonics applications including light emission and photodetection. His more recent research focuses on coupling between optical and mechanical degrees of nanoscale systems.

Michael Gerhold

Michael Gerhold is the Program Manager for Optoelectronics in the U.S. Army Research Office. He attended Purdue University and received BSEE ’92 with highest distinction and MSEE ’94 in optics and semiconductors. In 1995 he worked at Intel Corporation where he developed multi-level-cell “strata-flash” technology for flash memory. He later attended the University of Michigan where he received a Ph.D. . ’99 in solid state electronics. Since 1999 he has been a program manager for optoelectronics at the Army Research Office. His research program has three main thrusts: mid-IR and high power lasers, high-speed lasers and interconnects, and UV-visible optoelectronics. His tenure at ARO has enabled him to do “staff research” at North Carolina State University and Duke University on a part-time basis. Currently, his research focuses on III-Nitride semiconductors. Also, he has done work on nanoplasmonics and SERS substrates for biomolecule sensing.

Peter Heim

Peter J.S Heim is CTO and General Manager of Thorlabs Quantum Electronics, Inc., a wholly owned subsidiary of Thorlabs Inc., with vertically integrated manufacturing capability for both III-V semiconductor and lithium niobate optical devices. Dr. Heim was the co-founder of Quantum Photonics, Inc. and its successor Covega Corporation, where he was actively involved in establishing a successful product family of tunable gain chips, SOAs, SLDs and laser diodes. Dr. Heim was formerly a research faculty member at the University of Maryland and has worked extensively to develop high-power semiconductor lasers, semiconductor optical amplifiers, and tunable lasers. Prior to this he was a member for the technical staff at the MITRE Corporation working on mm-wave satellite communication systems. He has published more than 30 technical papers and has numerous patents. He holds a Ph.D. in electrical engineering from the University of Maryland, and a B.A. and M.A., both in physics, from Dartmouth College.

Boubacar Kante

Grounded on the fundamental physical principles, and, the on-demand dimensionality of materials and nanomaterials, his research addresses tantalizing experimental and theoretical physical questions in the field of nano-optics and intelligent nano-materials to address global energy, defense, and health questions. He is particularly interested in the theoretical modeling, fabrication and characterization of metamaterials for application in information science. Kante’s recent research has focused on artificial electromagnetic composites -- metamaterials. He demonstrated the first non-magnetic metamaterial invisibility cloak, introduced the notion of index for a meta-surface, and, the notion of symmetry/parity of ring resonators. Prof. Kante also demonstrated, from symmetry consideration, that closed rings, previously believed incapable of producing artificial magnetism, can make ultra-broadband negative index.

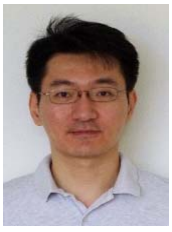
Mercedeh Khajavikhan

Professor Mercedeh Khajavikhan is an Assistant Professor of CREOL the College of Optics and Photonics at University of Central Florida. She received her Ph.D. in Electrical Engineering from University of Minnesota in 2009, and was subsequently a postdoctoral researcher in NSF Center for Integrated Access Network (CIAN) and Electrical Engineering at UC San Diego. In 2012 she joined the faculty at CREOL. She has over 50 publications (journal: 17 and conference: 35) publications and over 20 invited talks and seminars. She is a member of OSA, SPIE, and IEEE. Her areas of research include non-Hermitian photonics, novel semiconductor lasers, nanophotonics and plasmonics. In particular, she is an expert in fabricating and characterizing complex semiconductor lasers based on photonic structures. She is the recipient of NSF CAREER Award (2015) and ONR Young Investigator Award (2016).

Jacob Khurgin

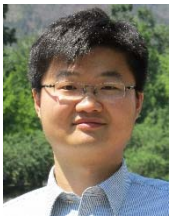
Jacob B Khurgin has been a Professor of Electrical and Computer Engineering at Johns Hopkins University since he remembers himself, or, more precisely, since 1988. Prior to that he vaguely recalls being a Senior Member of Research Staff at Philips NV where he developed various useful things such as small kitchen appliances, lighting fixtures, display components and systems including 3-D projection TV. Satiated by things useful, Prof. Khurgin had decamped industry for academia to immerse himself into topics of dubious utility yet higher entertainment value. Prof. Khurgin's main area of expertise is difficult to pinpoint as it falls into the gap between optics and solid state electronics. In his 28 years at JHU Prof. Khurgin had made contributions of various degrees of relevance and importance in the fields of nonlinear optics, semiconductor optoelectronic devices, quantum-cascade lasers, optical communications, THz technology, microwave photonics, slow light, plasmonics, laser cooling, opto-mechanics, condensed matter physics, and to other fields that he can no longer recall. Prof Khurgin had authored over 320 technical papers, 500 Conference presentations, 5 book chapters, and 35 patents. More importantly, he is very fond of dogs and bicycles and he is also a Fellow of American Physical Society and Optical Society. Prof. Khurgin holds Ph.D. from Polytechnic University of New York (Now elevated to the status of NYU school of Engineering).

Ning Li



Ning Li has a B.S. from Tsinghua University, Beijing, China, and a Ph.D. from the University of Texas at Austin. He is a research staff member at IBM T. J. Watson Research Center. His current research interests include nanoscale materials and devices, optoelectronic devices and systems, photovoltaics and energy harvesting, solid state lighting and display, sensors, organic electronics, flexible and wearable electronics, devices and components for internet of things.

Renmin Ma, Host



Ren-Min Ma, Peking University, China Professor Ren-Min Ma's research team seeks scientific innovation on the novel physical phenomena and applications arising from the interplay between nanomaterials and electronics, photonics and quantum optics. They developed the first room temperature semiconductor plasmon laser, directionally emitted WEB plasmon laser and applied plasmon lasers to sensing field. They recently proposed a vortex laser at exceptional point. Their current research interests include plasmon lasers, vortex lasers, PT synthetic optics and active nanomaterials.

Zetian Mi

Zetian Mi is a Professor in the Department of Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor, and an Adjunct Professor in the Department of Electrical and Computer Engineering at McGill University, Montreal, Canada. He received the Ph.D. degree in Applied Physics from the University of Michigan, Ann Arbor in 2006. Prof. Mi's teaching and research interests are in the areas of III-nitride semiconductors, low dimensional nanostructures, LEDs, lasers, Si photonics, and solar fuels. He has published 10 book chapters and over 180 journal papers on these topics. His group has pioneered in the epitaxy of III-nitride dot-in-nanowire heterostructures and has demonstrated, for the first time, electrically injected semiconductor lasers operating in the UV-B (280-315 nm) and UV-C (200-280 nm) bands, with threshold current densities two to three orders of magnitude lower compared to conventional GaN quantum well lasers. Prof. Mi has received the Young Scientist Award from the International Symposium on Compound Semiconductors in 2015 and the Young Investigator Award from the 27th North American Molecular Beam Epitaxy Conference in 2010. Most recently, Prof. Mi was an Associate Professor of Electrical & Computer Engineering at McGill University, where he received several major awards including the Engineering Innovation Award. Prof. Mi served as the Program Chair of the 30th North American Conference on Molecular Beam Epitaxy in 2013 and is the General Chair of 2016-2017 IEEE Photonics Society Summer Topical Meeting.

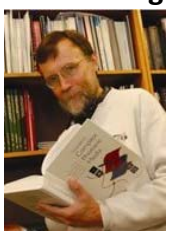
Maiken Mikkelsen

Maiken H. Mikkelsen is the Nortel Networks Assistant Professor of Electrical and Computer Engineering and Assistant Professor of Physics at Duke University. Her research interests span ultrafast phenomena in artificially structured materials, nanophotonics, plasmonics, light-matter interactions in quantum confined structures, spin phenomena in the solid state, and quantum information science. She received her B.S. in Physics from the University of Copenhagen, Denmark in 2004, and her Ph.D. in Physics from the University of California, Santa Barbara in 2009 in the group of Prof. David Awschalom. Before joining Duke in 2012, she was a postdoctoral fellow with Prof. Xiang Zhang at the University of California, Berkeley. Her awards include the Army Research Office Young Investigator Award (2016), the Cottrell Scholar Award from the Research Corporation for Science Advancement (2016), the NSF CAREER award (2015), the Air Force Office of Scientific Research Young Investigator Award (2015) and the Ralph E. Powe Junior Faculty Award (2014).

Cun-Zheng Ning

Cun-Zheng Ning received his Ph.D. in Physics from the University of Stuttgart, Germany. He has published over 170 journal papers in the areas of laser physics, geometric phases, quantum optics, semiconductor optoelectronics, many-body physics in semiconductors, nanophotonics and nanolasers. He has also given over 170 invited, plenary, or colloquium talks worldwide. He was a senior scientist, nanophotonics group leader, and nanotechnology task manager at NASA Ames Research Centre from 1997 to 2007, and an ISSP Visiting Professor at University of Tokyo in 2006, and at Technical University of Berlin and Tsinghua University in Beijing in 2013. Since 2006, he has been professor of electrical engineering and affiliate professor in physics and in materials science and engineering at Arizona State University. He was a winner of several awards including NASA and NASA contractor Achievement Awards, NASA Space Act Patent Awards, CSC Technical Excellence Award, and IEEE/Photonics Society Distinguished Lecturer from 2007-2009. Dr. Ning is a Fellow of the Optical Society (OSA), IEEE, and Electromagnetic Academy.

Mikhail Noginov



Dr. Mikhail A. Noginov graduated from Moscow Institute for Physics and Technology (Moscow, Russia) with a Master of Science degree in Electronics and Automatics in 1985. In 1990 he received a Ph.D. degree in Physical-Mathematical Sciences from the General Physics Institute of the USSR Academy of Sciences (Moscow, Russia). In 1985-1991, Dr. Noginov worked as an Engineer, Junior Staff Research Scientist, and then Staff Research Scientist in the General Physics Institute of the USSR Academy of Sciences. In 1991-1993, he was a Postdoctoral Research Associate in the Center for Materials Science and Engineering at Massachusetts Institute of Technology, Cambridge, MA, USA. Between 1993 and 1997, Dr. Noginov was an Assistant Research Professor and then Associate Research Professor in the Department of Physics at Alabama A&M University, Huntsville, AL, USA. In 1997, Dr. Noginov has joined Norfolk State University where he started as a Research Associate Professor, and then, as a teaching faculty, advanced in ranks from an Assistant Professor to a Professor (Department of Physics and Center for Materials Research.) In 2010, Dr. Noginov was named Norfolk State University Eminent Scholar 2010-2011. Dr. Noginov has published three books, six book chapters, over 100 papers in peer reviewed journals, over 100 publications in proceedings of professional societies and conference technical digests (many of them invited). Dr. Noginov is a member of OSA, SPIE, and APS. He has served as a chair and a committee member of several conferences of SPIE and OSA. He regularly serves on NSF panels and reviews papers for many professional journals. Since 2003, Dr. Noginov is a faculty advisor of the OSA student chapter at NSU.

Rupert Oulton, Host

Rupert F. Oulton is a UK Engineering and Physical Sciences Research Council Fellow and Leverhulme Lecturer at Imperial College London, since 2010. He graduated with a Ph. D. in physics from Imperial College London on the physics of wavelength scale semiconductor opti- cal devices and went onto research plasmonics and metamaterials at UC Berkeley as a Research Associate. His current research interests include the linear and nonlinear optics of metallic nanostructures, metal-based “plasmonic” lasers and quantum optics.

Si Hui Pan

Si Hui "Athena" Pan received her B.S. degree in physics in 2010 from Brandeis University, Waltham, MA, USA, and her M.S. degree in physics in 2013 from University of California at San Diego, La Jolla, CA, USA, where she is currently pursuing a Ph.D. in physics. Her research interests include the fabrication and characterization of nanophotonic devices, solid-state physics and quantum optics. Specifically, she is focusing on the investigation of coherent and dynamical effects in semiconductor nanolasers based on multiple-quantum-well and quantum-dot gain media. Prior to graduate school, she held a research staff position for two years at the Massachusetts Institute of Technology Lincoln Laboratory, Lexington, MA, USA, where she participated in the research and development of superconducting nanowire single photon detectors. She has held undergraduate research positions at the Daghlian Ion Accelerator Lab at Connecticut College, the Laboratory for Elementary Particle Physics of Cornell University and the National Nanotechnology Infrastructure Network at Harvard University, where she investigated the optical properties of silicon supersaturated with chalcogens for her undergraduate honors thesis. Upon receiving her B.S. degree, Athena was awarded a research internship position at the National Institute for Material Science, Tsukuba, Ibaraki, Japan. She is the recipient of the National Science Foundation Graduate Research Fellowship, the Physics Excellence Award from University of California at San Diego and the Physics Faculty Prize from Brandeis University.

Matthew Pelton

Matthew Pelton received a B.A.Sc. in Engineering Physics from the University of Toronto in 1996 and a Ph.D. in Applied Physics from Stanford University in 2002. Following postdoctoral positions at the Royal Institute of Technology in Sweden and at the University of Chicago, he joined the Center for Nanoscale Materials at Argonne National Laboratory, where he was a scientific staff member from 2006 until 2013. In fall 2013, he joined the Department of Physics at the University of Maryland, Baltimore County.

Christopher Pinzone

Dr. Christopher J. Pinzone received his doctorate in Ceramics and Materials Science and Engineering from Rutgers University. He was a Member of the Technical Staff at Bell Laboratories in Murray Hill from 1982 to 2000, where he grew the first room temperature CW laser directly on silicon, and the first optically pumped VCSEL at 1.55 microns. He pioneered heavy tin doping in InP based materials by MOCVD in order to achieve record high gain, high bandwidth heterojunction bipolar transistors, and studied diffusion of Zn and Sn in III-V materials. His research on heterostructure interfaces lead to him setting up pilot production of AT&T's 1.3 micron analog laser allowing for cable TV transmission expansion to 110 channels. He transferred the Electro-Modulated Laser (EML) product to the factory and developed a new technique for direct wafer bonding of InGaAs to silicon which lead to record low noise avalanche photo detectors. Joining Coretek in 2000, he expanded capacity for production of MEMS tunable VCSELS prior to its $1.4B purchase by Nortel. In 2002 he cofounded Ahura Scientific, which developed and produced the world's first handheld Raman and FT-IR spectrometers for field service, and developed etched and regrown DFBs in AlGaAs for further

miniaturization, leading to the sale of the company to Thermo Fisher Scientific in 2010. After the sale, he stayed on and was responsible for development and production of visible lasers. He joined Thorlabs Quantum Electronics in 2015 to expand their laser materials capacity with a new facility, integrating the acquired Corning laser group. Dr. Pinzone has authored 27 journal articles, given over 30 conference presentations, and holds nine US and international patents. He is a member of the IEEE and a reviewer for Journal of Crystal Growth, Photonics Technology Letters, and the Journal of Applied Physics.

Vladimir Shalaev

Vladimir M. Shalaev, Scientific Director for Nanophotonics at Birck Nanotechnology Center and Distinguished Professor of Electrical and Computer Engineering at Purdue University, specializes in nanophotonics, plasmonics, and optical metamaterials. Vladimir M. Shalaev has received several awards for his research in the field of nanophotonics and metamaterials, including the Max Born Award of the Optical Society for his pioneering contributions to the field of optical metamaterials, the Willis E. Lamb Award for Laser Science and Quantum Optics, Rolf Landauer medal of the ETOPIM (Electrical, Transport and Optical Properties of Inhomogeneous Media) International Association, the UNESCO Medal for the development of nanosciences and nanotechnologies and IEEE Photonics Society William Streifer Scientific Achievement Award. He is a Fellow of the IEEE, APS, SPIE, MRS and OSA. Prof. Shalaev has authored three books, twenty-eight invited book chapters and over 400 research publications.

Volker Sorger, Host

Volker J. Sorger is an assistant professor in the Department of Electrical and Computer Engineering, and the director of the Orthogonal Physics Enabled Nanophotonics (OPEN) lab at the George Washington University. He received his Ph.D. from the University of California Berkeley. His research areas include opto-electronic devices, plasmonics and nanophotonics, including novel materials. Dr. Sorger received multiple awards such as the AFOSR young investigator award, MRS Graduate Gold award, Intel Fellowship, and Outstanding young researcher award at GWU. Dr. Sorger is the OSA executive co-chair for technical group development, and member of the Board-of-Meetings at OSA and SPIE. He is the editor-in-chief for the journal 'Nanophotonics', CTO of BitGrid LLC, and member of IEEE, OSA, SPIE, and MRS.

Ganapathi Subramania

Dr. Ganapathi Subramania is a Technical Staff member in Semiconductor materials and device sciences department of Sandia National Laboratories in Albuquerque, NM. He received his Bachelor of Technology in Electrical Engineering (1992) from the Indian Institute of Technology, Chennai, India). He received his Ph.D in Electrical engineering and Applied Physics (2000) from Iowa State University. There he worked on design, fabrication and characterization of visible frequency photonic crystals based on colloidal nanospheres for which he received a US Patent in 2002. Then he joined the Department of Material Science at MIT as a postdoctoral associate in 2000 and worked on biocompatible photonic crystals. He first joined Sandia in 2001

as a postdoctoral researcher working on III-V based 2D photonic crystals. Currently, a staff member, his primary research interest is on nanoscale structures for enhancing light-matter interaction and quantum information science. Of particular interest is spontaneous/stimulated emission control, cavity quantum electrodynamics and non-classical light generation utilizing photonic crystals, metamaterials and metal optics structures.

Shuai Sun

Shuai Sun was born in Henan, China in 1990. He received the B.S. degree from North China Electric Power University (Beijing) in 2012 major in Automation and M.S. degree from George Washington University in 2014 major in Electrical Engineering. He started his Ph.D. program in George Washington University since 2015 as a research assistant in the Nanophotonic Lab leads by Prof. Volker J. Sorger. His research area includes optical NoCs in the levels of nano-devices and network architectures, photonic-plasmonic hybrid interconnects, optical computing, optical neural networks and nanophotonic devices. He is now working on a project which brings together expertise in nano-plasmonics, optoelectronic, architecture, reconfigurable technologies and HPC to address next generation network on chip (NoC) for the future optical computing and sponsored by AFOSR.

Danqing Wang

I am a Ph.D. candidate in the Applied Physics program of Northwestern University and currently co-advised by Prof. Teri W. Odom and Prof. George C. Schatz. Before coming to Northwestern, I received my B.A. degree in Physics from Nanjing University, China. My research focuses on the light-matter interaction between gain medium and plasmonic nanocavity arrays. This work involves a combination of nanofabrication, optical characterization as well as electrodynamic simulations with finite-difference-time-domain (FDTD) methods. A primary goal of my work is to apply nanomaterial design to light generating and information storage for on-chip photonic integration.

Ming Wu

Ming C. Wu is Nortel Distinguished Professor of Electrical Engineering and Computer Sciences at the University of California, Berkeley. He is also Co-Director of Berkeley Sensor and Actuator Center (BSAC) and Faculty Director of UC Berkeley Marvell Nanolab. Dr. Wu received his B.S. degree in Electrical Engineering from National Taiwan University, and M.S. and Ph.D. degrees in Electrical Engineering and Computer Sciences from the University of California, Berkeley in 1986 and 1988, respectively. From 1988 to 1992, he was Member of Technical Staff at AT&T Bell Laboratories, Murray Hill, New Jersey. From 1992 to 2004, he was Professor of Electrical Engineering at the University of California, Los Angeles (UCLA). He has been a faculty member at Berkeley since 2004. His research interests include semiconductor optoelectronics, nanophotonics, MEMS, MOEMS, and optofluidics. He has published 8 book chapters, over 500 papers in journals and conferences, holds 23 U.S. patents. Prof. Wu is a Fellow of IEEE. He was a Packard Foundation Fellow (1992 – 1997), and received the 2007 Paul F. Forman Engineering Excellence Award from Optical Society, and the 2016 William Streifer Award from IEEE Photonics Society.

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OSA Subwavelength Photonics Incubator

21-23 September 2016
Washington, DC USA

HOSTED BY:
Pavel Cheben, National Research Council, Canada
Iñigo Molina Fernandez, University of Malaga, Spain
David Smith, Duke University, United States
Weidong Zhou, University of Texas at Arlington, United States

Agenda

Wednesday, 21 September 2016

Afternoon	Arrival/Hotel Check-in Washington Hilton, 1919 Connecticut Ave NW, Washington, DC
18:00	Welcome Dinner Madrid, 1714 Connecticut Ave NW, Washington, DC

Thursday, 22 September 2016

8:00	Breakfast AGU Building, 2000 Florida Ave NW, Washington, DC
8:30	**Welcome** *Liz Rogan, The Optical Society*
8:45	**Program Overview and Goals** *Hosts*
9:00	**Photonic Crystal Waveguides, Bloch Waves & Subwavelength Photonics** *Philip Russell, Former OSA President* *Max Planck, Institute for the Science of Light, Germany*
9:40	**Discussion**
9:50	**Subwavelength Silicon Photonics** *Siegfried Janz, National Research Council, Canada*
10:30	**Discussion**

10:40 Coffee Break

SESSION 1: Optical Metamaterials and Metasurfaces, David Smith, Duke University, United States

11:00 **Few-Layer Terahertz Metasurfaces for Antireflection, Polarization Conversion & Flat Lens**
Houtong Chen, Los Alamos National Lab, United States

11:20 **Electronically Tunable Metasurface Phased Arrays**
Harry Atwater, Caltech, United States

11:40 **Dielectric Metasurfaces**
Mohammadreza Khorasaninejad, Harvard University, United States

12:00 **Discussion – Metamaterials: Challenges and Promises**
Lead: David Smith, Duke University, United States

12:20 Lunch, provided

SESSION 2: Nanoscale Structures in Dielectric Waveguides I, *Miloš Popović*, Boston University, United States

13:20 **Ultra High Confinement in Silicon Photonics**
Michal Lipson, Columbia University, United States

13:40 **Metamaterial Interfaces for Coupling Standard Fibers to Nanophotonic Waveguides**
Tymon Barwicz, IBM, United States

14:00 **Subwavelength Index Engineering for SOI Waveguides**
Robert Halir, University of Malaga, Spain

14:20 **Discussion – Subwavelength Engineered Waveguides: Challenges & Promises**
Lead: Miloš Popović, Boston University, United States

14:40 Coffee Break

SESSION 3: Nanoscale Structures in Dielectric Waveguides II, Tymon Barwicz, IBM, United States

15:00 **Subwavelength Structures for CMOS Electronics-Photonics Integration**
Miloš Popović, Boston University, United States

15:20 **Subwavelength Engineered Surface Grating Couplers**
Carlos A. Ramos, Université Paris Saclay, France

Thursday, 22 September 2016, continued

15:40 **Photonic Crystal Microcavity Devices in SOI Waveguides**
Jeff Young, University of British Columbia, Canada

16:00 **Discussion – Industrial Applications, Manufacturability & Markets**
Lead: Tymon Barwicz, IBM, United States

SESSION 4: Light Interaction with Metal Nanostructures, Pierre Berini, University of Ottawa, Canada

16:20 **Metallic Nanostructures for Active Control of Light**
Alexey Krasavin, King's College London, UK

16:40 **Surface Plasmon Enhanced Optoelectronics: Application to Contactless Si Wafer Probing**
Pierre Berini, University of Ottawa, Canada

17:00 **Photonics at the Atomic Scale**
Javier Aizpurua, Center for Materials Physics & DIPC, Spain

17:20 **Discussion – Plasmonics: Challenges & Promises**
Lead: Pierre Berini, University of Ottawa, Canada

17:40 **DAY 1 Wrap-Up**

18:00 Network Dinner
Bistro Bistro, 1727 Connecticut Ave NW, Washington

Friday, 23 September 2016

8:00 Breakfast
AGU Building, 2000 Florida Ave NW, Washington, DC

8:30 **Metamaterial and Plasmonic Components for Subwavelength Photonic Devices**
David Smith, Duke University, United States

9:10 **Discussion**

9:20 **Subwavelength Plasmonic Structures**
Vladimir M. Shalaev, Purdue University, United States

10:00 **Discussion**

10:10 Coffee Break

SESSION 5: Exploring Frontiers: Photonics Crystals, Subwavelength Engineered Nanostructures and Metamaterials, David A.B. Miller, Stanford University, United States

10:50 **Modeling Nanoresonators with Their Resonance Modes**
Philippe Lalanne, L'Institut D'Optique, CNRS, France

11:10 **High Index Dielectric Optical Meta-surfaces with Broken Vertical Symmetry**
Pierre Viktorovitch, Ecole Centrale de Lyon, France

11:30 **Deep Sub-Wavelength Photonics: Persistent Heat Current, and Multi-Resonant Antenna**
Shanhui Fan, Stanford University, United States

11:50 **Discussion - Subwavelength Photonics: Future Prospects**
Lead: David A. B. Miller, Stanford University, United States

12:10 Final Wrap-Up

12:30 Lunch, provided

13:30 Adjournment