JOSEPH STEPHEN THOMAS SMALLEY

cell phone: 814.602.8117
email: jsmalley@eng.ucsd.edu
website: http://emerald.ucsd.edu/Members/Joseph.html

ACADEMIC DEGREES

Ph.D., Electrical Engineering (Nanoscale Devices and Systems)
University of California San Diego, June 2016

M.S., Electrical Engineering (Nanoscale Devices and Systems)
University of California San Diego, 2013

B.S., Engineering Science (with distinction and honors)
Pennsylvania State University, 2011

AREAS OF INTEREST:

Nanophotonics: study and manipulation of the nanoscale interaction between light and matter for next generation sensing, communication, and energy harvesting platforms; **Plasmonics:** sub-diffraction limited optics for achieving ultra-fast, -compact, and energy-efficient photonic devices and circuits; **Metamaterials:** study and design of engineered composite materials with unique properties such as negative refraction and extreme polarization anisotropy; **Active and Nonlinear Electromagnetics:** fundamental studies of media with gain and nonlinearities and their application in integrated sources, modulators, and detectors; **Smart Cities:** applications of photonics to the Smart Cities paradigm, including lighting, communications, sensing, and signal processing; **Complexity**: study of complex dynamics in nonlinear physical and social systems.

ACADEMIC POSITIONS

June 2016 – present	Post-Doctoral Scholar Department of Electrical & Computer Engineering University of California San Diego La Jolla, CA 92093
June 2015 – Sept 2015	Visiting Researcher Center for Integrated Nanotechnologies Sandia National Laboratory Albuquerque, NM 87545
2012 – 2016	Graduate Research Assistant Department of Electrical & Computer Engineering University of California San Diego La Jolla, CA 92093

PEER-REVIEWED PUBLICATIONS

20. L. Ferrari, **J. S. T. Smalley**, Y. Fainman, Z. Liu, "Hyperbolic metamaterials for dispersion-assisted directional emission," *Nanoscale* 9, 9034-9048 (2017)

19. C. Fang, F. Vallini, A. El Amili, **J. S. T. Smalley**, Y. Fainman, "Low Resistance Tunnel Junctions for Efficient Electrically Pumped Nanolasers," *IEEE Journal of Selected Topics in Quantum Electronics* 23(6), 1-6 (2017)

18. C. T. Riley, **J. S. T. Smalley**, J. R. J. Brodie, Y. Fainman, D. J. Sirbuly, Z. Liu, "Near perfect broadband absorption from hyperbolic metamaterial nanoparticles," *Proceedings of the National Academy of Sciences of the U.S.A*, 114(6), 1264-1268 (2017)

17. **J. S. T. Smalley**, F. Vallini, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Luminescent hyperbolic metasurfaces," *Nature Communications* 7, 13793 (2017)

16. **J. S. T. Smalley**, F. Vallini, Q. Gu, Y. Fainman, "Amplification and lasing of plasmonic modes," *Proceedings of the IEEE* 104(12), 2323-2337 (2016)

15. **J. S. T. Smalley**, F. Vallini, A. El Amili, Y. Fainman, "Photonics for smart cities," in *Smart Cities Technologies*, ed: I. N. da Silva and R. A. Flauzino, Intech, 19-40 (2016)

14. C. T. Riley, **J. S. T. Smalley**, K. W. Post, D. N. Basov, Y. Fainman, D. Wang, Z. Liu, D. J. Sirbuly, "High-quality, ultraconformal aluminum doped zinc oxide nanoplasmonic and hyperbolic metamaterials," *Small* 12(7), 892-901 (2016)

13. **J. S. T. Smalley**, F. Vallini, S. Shahin, B. Kanté, Y. Fainman, "Gain-enhanced high-k transmission through metal-semiconductor hyperbolic metamaterials," *Optical Materials Express* 5(10), 2300-2312 (2015)

12. O. Bondarenko, C. Fang, F. Vallini, **J. S. T. Smalley**, Y. Fainman, "Extremely compact hybrid III-V/SOI lasers: design and fabrication approaches," *Optics Express* 23(3), 2696-2712 (2015)

11. Q. Gu, **J. S. T. Smalley**, J. Shane, O. Bondarenko, Y. Fainman, "Temperature effects in metal-clad semiconductor nanolasers," *Journal of Nanophotonics* 4(1), 26-43 (2015)

10. C. T. Riley, T. A. Kieu, **J. S. T. Smalley**, S. H. A. Pan, S. J. Kim, K. W. Post, A. Kargar, D. N. Basov, X. Pan, Y. Fainman, D. Wang, D. J. Sirbuly, "Plasmonic tuning of aluminum doped zinc oxide nanostructures by atomic layer deposition," *Physica Status Solidi RRL* 8(11), 948-952 (2014)

9. **J. S. T. Smalley**, F. Vallini, B. Kanté, Y. Fainman, "Modal amplification in active waveguides with hyperbolic dispersion at telecommunication frequencies," *Optics Express* 22(17), 21088-21105 (2014)

8. Q. Gu, J. Shane, F. Vallini, B. Wingad, **J. S. T. Smalley**, N. C. Frateschi, Y. Fainman, "Amorphous Al_2O_3 shield for thermal management in electrically pumped metallo-dielectric nanolasers," *IEEE Journal of Quantum Electronics* 15(7), 499-509 (2014)

7. M. W. Puckett, **J. S. T. Smalley**, M. Abashin, A. Grieco, Y. Fainman., "Tensor of the second-order nonlinear susceptibility in asymmetrically strained silicon waveguides: analysis and experimental validation," *Optics Letters* 39(6), 1693-1696 (2014)

6. Q. Gu, **J. S. T. Smalley**, M. P. Nezhad, A. Simic, J. H. Lee, M. Katz, O. Bondarenko, B. Slutsky, A. Mizrahi, V. Lomakin, Y. Fainman, "Sub-wavelength semiconductor lasers for dense chip-scale integration," *Advances in Optics and Photonics* 6(1), 1-56 (2014)

5. **J. S. T. Smalley**, Q. Gu, Y. Fainman, "Temperature dependence of the spontaneous emission factor in subwavelength semiconductor lasers," *IEEE Journal of Quantum Electronics* 50(3), 175-185 (2014)

4. **J. S. T. Smalley**, M. W. Puckett, Y. Fainman, "Invariance of optimal composite waveguide geometries with respect to permittivity of the metal cladding," *Optics Letters* 38(23), 5161-5164 (2013)

3. Q. Gu, B. Slutsky, F. Vallini, **J. S. T. Smalley**, M. P. Nezhad, N. C. Frateschi, Y. Fainman., "Purcell effect in sub-wavelength semiconductor lasers," *Optics Express* 21(13), 15603-15617 (2013)

2. **J. S. T. Smalley**, Y. Zhao, A. A. Nawaz, Q. Hao, Y. Ma, I. C. Khoo, T. J. Huang, "High-contrast modulation of plasmonic signals using nanoscale dual-frequency liquid crystals," *Optics Express* 19(16), 15265-15274 (2011)

1. Y. J. Liu, Q. Hao, **J. S. T. Smalley**, J. Liou, I. C. Khoo, T. J. Huang, "A frequency-addressed plasmonic switch based on dual-frequency liquid crystal," *Applied Physics Letters* 97, 091101 (2010)

CONFERENCE PRESENTATIONS (*presenting author)

15. **J. S. T. Smalley***, F. Vallini, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Extreme anisotropy, spectral modification, and intensity enhancement in luminescent hyperbolic metasurfaces," CLEO 2017, Symposium on Advances in Metaphotonic Devices I, paper JW1G.5, San Jose, CA May 17, 2017 (Finalist, Tingye Li Innovation Prize)

14. **J. S. T. Smalley***, F. Vallini, Y. Fainman, "Nanoscale polarimeter based on luminescent hyperbolic metasurfaces," OSA Biophotonics Congress, Bio-Optics: Design and Application, paper BoS2A.5, San Diego, CA, Apr 2, 2017

13. **J. S. T. Smalley***, F. Vallini, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Extreme photoluminescence anisotropy in active hyperbolic metasurfaces," SPIE Optics & Photonics, paper 9918-71, San Diego, CA, Aug 31, 2016

12. **J. S. T. Smalley***, F. Vallini, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Near-infrared meta-gain media based on hyperbolic metasurfaces," SPIE Optics & Photonics, paper 9920-44, San Diego, CA, Aug 30, 2016 (Finalist, Best student paper)

11. **J. S. T. Smalley**, F. Vallini*, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Fabrication and characterization of InGaAsP/Ag luminescent hyperbolic metamaterials", SBMicro2016, paper 9920-44, Brazil, Aug 2016 (Winner, Best overall paper)

10. **J. S. T. Smalley***, F. Vallini, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Active hyperbolic metasurfaces at telecommunication frequencies," Progress in Electromagnetics Research Symposium 2016, paper 160405142507, Shanghai, China, Aug 8, 2016

9. **J. S. T. Smalley***, F. Vallini, S. Montoya, L. Ferrari, S. Shahin, C. T. Riley, B. Kanté, E. E. Fullerton, Z. Liu, Y. Fainman, "Light-emitting hyperbolic metasurfaces at telecommunication frequencies," OSA Advanced Photonics Congress, paper NoM3C.3 Vancouver, BC, July 18, 2016

8. F. Vallini*, S. Shahin, F. Monifi, **J. S. T. Smalley**, M. Rabinovich, Y. Fainman, "Solving optimization problems with coupled dynamical elements," IEEE Photonics Society Summer Topical Meeting, Newport, CA, July 12, 2016

7. **J. S. T. Smalley***, F. Vallini, S. Montoya, E. Fullerton, Y. Fainman, "Practical realization of deeply subwavelength multilayer metal-dielectric nanostructures based on InGaAsP," SPIE Optics & Photonics, paper 9544-23, San Diego, CA, Aug 10, 2015

6. **J. S. T. Smalley***, F. Vallini, B. Kanté, S. Shahin, C. Riley, Y. Fainman, "Gain-enhanced hyperbolic metamaterials at telecommunication frequencies," SPIE Optics & Photonics, paper 9544-13, San Diego, CA, Aug 9, 2015

5. **J. S. T. Smalley***, F. Vallini, B. Kanté, Y. Fainman, "General conditions for lossless propagation in near-infrared hyperbolic metamaterial waveguides," CLEO 2015, paper FM3C.5, San Jose, CA, May 11, 2015

4. M. W. Puckett*, **J. S. T. Smalley**, M. Abashin, A. Grieco, Y. Fainman, "Analysis and characterization of optical nonlinearities induced in strained silicon," OSA Advanced Photonics for Communications, paper IW3A.7, San Diego, CA, July 2014

3. M. W. Puckett*, **J. S. T. Smalley**, Y. Fainman, "Recent advancements of strained silicon as an optically nonlinear material," CLEO 2014, paper Stu3H.1, San Jose, CA, June 2014

2. **J. S. T. Smalley*,** Q. Gu, M. W. Puckett, Y. Fainman, "Metal-clad subwavelength semiconductor lasers with temperature-insensitive spontaneous hyper-emission," CLEO 2014, paper JTh2A.74*,* San Jose, CA, June 2014

1. **J. S. T. Smalley*,** Q. Gu, M. W. Puckett, Y. Fainman, "Temperature dependencies of metal-clad subwavelength semiconductor lasers (MCSELs): geometric invariance and the spontaneous emission factor," SPIE Photonics West, Proc. SPIE 8980, Physics and Simulation of Optoelectronic Devices XXII 89800X, San Francisco, CA, Feb 2014

TEACHING & OUTREACH EXPERIENCE

2016	Graduate The College Classroom, Teaching & Learning Commons Center for Integrated Research, Teaching, and Learning Network University of California San Diego
2015	Teaching Assistant Optical Information Processing & Holography University of California San Diego
2013 – 2014	Teaching Assistant Photonics Cluster California State School for Science and Mathematics (COSMOS)
2011 – present	Outreach co-coordinator and participant NSF Engineering Research Center for Integrated Access Networks

RESEARCH EXPERIENCE

Investigation of CMOS compatible metamaterials for chip scale integration of photonic circuits
Ultrafast and Nanoscale Optics Group, UC San Diego, 2016
PI: Prof. Yeshaiahu Fainman

As a post-doc scholar I am simultaneously broadening my study of active hyperbolic metamaterials by investigating new material systems, and deepening the understanding of my PhD work by applying self-consistent modeling and temporally resolved measurements to previously demonstrated material systems. Based on my expertise in hyperbolic metamaterials, I was invited to join a team led by Prof. Zhaowei Liu at UCSD, to create an ultra-fast, visible light emitting diode that utilizes spontaneous emission enhancement from hyperbolic dispersion. In this effort, I have assisted in developing an analytical description of efficient impedance matching between HMMs and their environment, in modeling carrier dynamics through numerical simulations, and in measuring the spontaneous emission lifetime of InGaN/GaN LEDs modified by the presence of Ag-based HMMs.
Concurrently, I am collaborating with Prof. Ortwin Hess of Imperial College London on developing theoretical tools for the self-consistent description of field-carrier interactions in HMMs designed, fabricated, and characterized at UCSD. To date, the research community is in need of more rigorous models to describe the complex dynamics of polaritons and charge carriers in semiconductor-metal HMMs. Finally, I am collaborating with post-docs of Prof. Donald Sirubly of UCSD in developing fabrication processes for integrating aluminum-doped zinc oxide, a CMOS compatible metal, with III-V semiconductors, for the possible construction of HMM-enhanced high-speed light sources at near-infrared frequencies.

Active and tunable near-infrared hyperbolic metamaterials
Ultrafast and Nanoscale Optics Group, UC San Diego, 2014-2016
PI: Prof. Yeshaiahu Fainman

As a PhD student, I led a team of students, post-docs, and professors from multiple departments at UCSD, in the theory, design, fabrication, and characterization of active and tunable near-infrared hyperbolic metamaterials. Ultimately my work led to the creation and first demonstration of luminescent hyperbolic metasurfaces (LuHMS). LuHMS are hyperbolic metamaterials in which a semiconductor simultaneously functions as the constituent dielectric and quantum emitter. By distributing the emitters throughout the entire structure, light-matter interactions are maximized. Additionally, the design of the LuHMS enables efficient extraction of in-plane surface modes, the extreme polarization anisotropy of photoluminescence, and is amenable to electronic integration. Applications of the LuHMS include extremely high-speed and compact room-temperature LEDs, absorption modulators, and detectors of mid-IR light by two-photon absorption. In the design of the LuHMS, I derived closed-form expressions for lossless propagation in metal-dielectric hyperbolic metamaterials (HMMs) using effective medium theory; developed MatLab implementations of the transfer matrix method for calculating transmission of electromagnetic waves through multilayer HMMs; performed scattering matrix method and finite-difference time-domain simulations (Lumerical®) of wave propagation through HMMs with optical gain; fabricated Ag/InGaAsP HMM nanostructures using e-beam lithography, reactive-ion etching, metal sputtering, and focused ion beam milling; and measured their pump-polarization dependent photoluminescence in the 1200 nm-1600 nm spectral range.

Additionally, I assisted fellow students in the development of tunable near-IR metamaterials, based on aluminum-doped zinc oxide (AZO). Because it depends on the concentration of aluminum, the plasma frequency of AZO may be controllably tuned to frequencies near the emission frequency of many III-V compounds. I performed analytical and numerical modeling, including explaining results of negative refraction experiments via the scattering matrix method, thus proving that ZnO/AZO nanostructures fabricated by my colleagues were indeed HMMs. My PhD work led to numerous first authored and co-authored papers, as well as conference presentations throughout North America and China.

Tunable mid-infrared metamaterials
Center for Integrated Nanotechnologies, Sandia National Laboratory, 2015
PI: Dr. Igal Brener

As a graduate student intern, I worked with post-docs and staff researchers in the group of Dr. Igal Brener, on the development of electronically controlled mid-infrared metamaterials. These structures hold promise for actively tunable focal plane arrays in both the short wave (3 μm - 5 μm) and long wave (8 μm - 12 μm) mid-IR spectral regions. I fabricated GaAs, InGaAs, and GaSb-based samples, designed for depletion layer modulation and intersubband absorption, using photolithography, wet etching, electron-beam metal deposition, and atomic layer deposition of oxide barrier layers. I then

characterized fabricated samples by measuring IV and CV behavior, as well as via ellipsometry. Additionally, I attempted to develop a recipe for atomic layer deposition of silver thin films, in a collaboration with Dr. John Nogan. Ultimately, this assisted the Center for Integrated Nanotechnologies in the planning of future equipment needs such as in-situ characterization of films grown by atomic layer deposition.

Temperature effects in high spontaneous emission factor semiconductor nanolasers
Ultrafast and Nanoscale Optics Group, UC San Diego, 2011-2014
PI: Prof. Yeshaiahu Fainman

As a Masters student, I developed my interests in active materials for use in nanophotonic light sources. In particular I studied the effects of temperature on important quantities in the design of nanoscale lasers, including the Purcell factor and spontaneous emission factor. I developed a MatLab library for calculating material gain in bulk and quantum-confined III-V semiconductors, which has been used extensively by myself and other group members on multiple projects. I used the finite-element method solver Comsol® to design optically pumped semiconductor nanolasers and fabricated nanolasers using e-beam lithography, dry-etching, PECVD of dielectrics and sputtering of metals. I further characterized these structures using a near-infrared micro-photoluminescence setup. My Masters work led to two first author publication and numerous co-authorships.

Morphology of polymer:bis-fullerene blends
Organic Photovoltaics Group, imec, Leuven, Belgium, 2011
PI: Dr. Barry Rand

Prior to beginning graduate school, I worked for 12 weeks as a visiting scholar in IMEC's organic electronics group. I fabricated thin film samples of polymer:bis-fullerene blends via spin-coating and annealing and characterized their morphology using atomic force microscopy. Ultimately my work contributed to the development of a repeatable procedure for the creation of high quality organic thin films used in photovoltaic devices.

High-contrast nanoscale plasmonic modulator based on liquid crystals
Biomedical Nano-electromechanical Systems Laboratory, Penn State University, 2010-2011
PI: Prof. Tony J. Huang

As a fourth year undergraduate student, I led a proof-of-concept project in collaboration with Prof. Tony Huang, Prof. I.C. Khoo, and several graduate students. I proposed a nanoscale plasmonic liquid-crystal electro-optic modulator as a potential all-optical transistor. To assess the concept, I performed extensive numerical simulations with commercial finite-difference time-domain software (Optiwave FDTD® and Lumerical®). Additionally, I assisted graduate students with measurements of transmission spectra

through liquid crystals and edited many of the group's manuscripts. My undergraduate thesis led to a first-author publication in Optics Express.

Characterization of novel thermoelectric materials
Optoelectronics Laboratory, University of California Santa Barbara, 2010
PI: Prof. John Bowers

Between my third and fourth undergraduate years, I worked for 10 weeks as a research assistant with Prof. John Bowers of UC Santa Barbara. In collaboration with Ashok Ramu, a post-doc, I designed and built an electronic circuit for measuring thermal conductivity of rare-earth doped-III/V semiconductors. The measurement system followed the 3ω method, which uses the 3rd harmonic of a voltage applied across the material of interest to extract thermal conductivity. This work enabled systematic characterization of the thermoelectric properties of engineered materials in Prof. Bowers' lab and confirmed my interest to pursue graduate-level research.

Improving the processing and testing of solid-oxide fuel cells
Electrochemistry Division, NASA Glenn Research Center, Cleveland, OH, 2009
PI: Dr. Serene Farmer

During my second year as an undergraduate I worked for 16 weeks as a research assistant at NASA's Glenn Research Center. Under the guidance of process engineers, I identified techniques for expedited testing of materials for the electrolytes in solid-oxide fuel cells. Additionally, I created a model for calculating solid-oxide fuel cell performance in Microsoft Excel, which aided research scientists in making more rapid assessment of experimental parameters.

Testing of hybrid electric-diesel locomotive control systems
General Electric Transportation, Erie, PA, 2008

During my first year as an undergraduate, I worked as an intern with GE Transportation for 12 weeks. Under the guidance of staff engineers, I wrote test plans for the vehicle control system and assisted in the testing of vehicle control systems.

RESEARCH SKILLS

- Extensive experience with software for theory, design, and analysis of optoelectronic materials and devices, including but not limited to *MatLab, Mathematica, Comsol, Lumerical, OptiFDTD, Silvaco, Nextnano, Layout Editor,* and *GIMP*.
- Extensive experience with standard micro- and nanofabrication equipment and processes, including but not limited to *electron beam* and *photo-lithography, dry* and *wet etching, atomic layer deposition, chemical vapor deposition, sputtering, electron beam evaporation, scanning electron,* and *atomic force microscopy*.
- Extensive experience characterizing optical and electrical properties of materials and devices including but not limited to measurement of emission spectra via *steady-state* and *time-resolved micro-photoluminescence* and *UV-Vis spectrophotometry,* material properties via *ellipsometry, Raman spectroscopy,* and I/V-C/V behavior of electronic devices via *4- and 6-point probe stations*.

PROFESSIONAL AND ACADEMIC ACTIVITIES

Peer-reviewer of professional journals, including:

- Progress in Quantum Electronics
- Advanced Materials
- Scientific Reports
- Optics Letters
- Optics Express
- Optical Materials Express
- Journal of Lightwave Technology
- IEEE Photonics
- IEEE Journal of Quantum Electronics
- Journal of Optics
- Applied Sciences

OTHER ACTIVITIES

- President, UC San Diego Student Leadership Committee, NSF Engineering Research Center for Integrated Access Networks, 2014-2015
- President, Graduate Student Council, Electrical & Computer Engineering, 2013-2014
- Vice President, Graduate Student Council, Electrical & Computer Engineering, 2012-2013

PROFESSIONAL SOCIETIES

- Member of IEEE
- Member of IEEE Photonics Society
- Member of OSA
- Member of SPIE

AWARDS AND HONORS

- Tingye Li Innovation Prize, Finalist, CLEO 2017
- Best Overall Paper, Winner, SBMicro2016
- Best Student Paper, Finalist, SPIE Active Photonic Materials Conference, 2016
- Rapid Access Proposal, Winner, Center for Integrated Nanotechnologies, Sandia National Laboratory, 2015
- Student Leadership Scholarship, NSF Center for Integrated Access Networks, 2015
- Best Poster, Second Prize, UC San Diego Optics Workshop, 2014
- NSF Graduate Student Fellowship, Honorable Mention, 2011
- Departmental Fellowship, UC San Diego, 2011
- Best Undergraduate Thesis, Winner, Engineering Science & Mechanics, Pennsylvania State University, 2011
- Best Undergraduate Portfolio, Finalist, Engineering Science & Mechanics, Pennsylvania State University, 2011

AWARDED PROPOSALS

- Atomic Layer Deposition of Silver Thin Films onto Nanostructured Compound Semiconductors for Active and Nonlinear Hyperbolic Metamaterial Waveguides
    - Awarding agency: Center for Integrated Nanotechnologies, Sandia National Laboratory, U. S. Department of Energy
    - Year: 2015
    - Role: Principal investigator and lead author
    - Amount: Unlimited 3-month access to user-based facilities

- Exploring the Frontier of Photonic Device Size, Speed, and Efficiency Limits with Gain-enhanced Multifunctional Metamaterials
    - Awarding agency: National Science Foundation
    - Award number: 1507146
    - Year(s): 2015 – 2018
    - Role: Co-author
    - Amount: $350,000

- Fundamental Investigations of Nanolaser Physics: Statistical Properties, Thermal Stability, and Temporal Dynamics of Light Emission
    - Awarding agency: National Science Foundation
    - Award number: 1405234
    - Year(s): 2014 – 2017
    - Role: Co-author
    - Amount: $350,000

- Optical Computing Multidisciplinary Research Initiative (MURI)
    - Awarding agency: Office of Naval Research
    - Year(s): 2015 – 2020
    - Role: Co-author
    - Amount: $1,250,000 (via University of Arizona prime)

- Near-Field Nanoscale Energy-Efficient Computing and Communications MURI
    - Awarding agency: Office of Naval Research
    - Year(s): 2013 – 2018
    - Role: Co-author
    - Amount: $7,500,000

OTHER TECHNICAL PRESENTATIONS

7. **J. S. T. Smalley** and Y. Fainman, "Luminescent hyperbolic metasurfaces," Annual program review, *Near-field energy-efficient communications and computation*, Office of Naval Research MURI, San Diego, CA, Aug 2016

7. **J. S. T. Smalley** and Y. Fainman, "Active and nonlinear hyperbolic metamaterials," Annual program review, *Near-field energy-efficient communications and computation*, Office of Naval Research MURI, San Diego, CA, Oct 2015

6. **J. S. T. Smalley**, "Active telecom hyperbolic metamaterials," NSF Center for Integrated Access Networks student talk, San Diego, CA, Jan 2015

5. **J. S. T. Smalley** and Y. Fainman, "Active and nonlinear hyperbolic metamaterials," Mid-year program review, *Near-field energy-efficient communications and computation*, Office of Naval Research MURI, San Diego, CA, Jan 2015

4. **J. S. T. Smalley** and Y. Fainman, "Quantronics," Annual program review, *Photonically optimized embedded microprocessors*, Defense Advanced Research Projects Agency, Scottsdale, AZ, Oct 2014

3. **J. S. T. Smalley** and Y. Fainman, "Active and nonlinear hyperbolic metamaterials," Annual program review, *Near-field energy-efficient communications and computation*, Office of Naval Research MURI, San Diego, CA, Oct 2014

2. **J. S. T. Smalley**, "Systematic investigation of morphology of polymer:bis-fullerene blends for bulk heterojunction organic photovoltaics," National Nanotechnology Infrastructure Network Research Experience for Undergraduates, Lueven, Belgium, Aug 2011

1. **J. S. T. Smalley**, "Characterization of materials with epitaxially embedded nanoinclusions for thermoelectric applications," National Nanotechnology Infrastructure Network Research Experience for Undergraduates, Minneapolis, MN, Aug 2010