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Welcome to 2020 Fall Virtual symposium of the Industrial Associates!

Thank you for participating and for your continuing support of the IA program and The Institute. In response to the COVID19 pandemic, we executed a remarkable transition this Spring. We shifted a program with almost no online instruction to an entirely online format. We made this move in strong headwinds. Our great strength, our faculty of highly accomplished and heavily decorated senior faculty, have taught with chalk on slate in front of live students for decades. Our two assistant professors are teaching new classes and are focused on approaching tenure review. Our teaching faculty had to accommodate multiple classes. Our adjuncts, many of whom have been loyal supporters of our program for years, overworked and underpaid, had their own day jobs, businesses and projects to manage in extremis as we asked them to make this journey with us. Our staff, already short-handed and dealing with all the special circumstances of supporting the nation’s premier optics department, provided the technical support, institutional infrastructure and innovation needed to move on line. They did this while serving the members of this, our Industrial Associates program, our recruiting events, and our numerous efforts to provide the career opportunities optics students have come to expect. It does not seem possible. And yet we did it. Amazing.

This Fall, we reopened the University and offered our world-class optics education to students both on campus and remote. As amazing as our transition to totally on-line instruction was, teaching in this new, mixed format has been more impressive still. Our extraordinary efforts have led to MS and undergrad enrollments that are actually up considerably over last year. And as you will hear from me Wednesday, we have jumped ahead in our plans for serving our community of working professionals in their ongoing educations and career development.

Our strength is derived in part from association with our industrial partners. Your direct financial support enables us to do great things for our students. Moreover, the opportunities you provide for our graduates to change the world are the mainstays of our reputation. With this in mind, I want to encourage suggestions from our members for future directions and initiatives you see for potential collaboration, making each other ever better.

We aim for our biannual IA meetings to provide unique opportunities for our members to interact with students and faculty in a special and authentic environment of intellectual exchange and growth. We hope you will be able to take full advantage of these opportunities and help us make IA an ongoing success.

Your participation in our IA program is greatly appreciated and we value your input. Thank you for being with us this Fall!

Meliora,

P. Scott Carney
Professor and Director, The Institute of Optics
# Agenda

**The Institute of Optics 2020 Fall Industrial Associates Symposium**  
**Wednesday, October 14 through Friday, October 16, 2020**

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**WEDNESDAY, October 14, 2020: 2:00PM – 5:00PM Eastern Time**  
All held virtually via REMO.

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<th>Time</th>
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<th>Topic</th>
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<tr>
<td>2:00 PM</td>
<td>Scott Carney, Professor &amp; Director, Inst Optics</td>
<td>Welcome and Institute of Optics Update</td>
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<tr>
<td>2:15 PM</td>
<td>Liz Rogan, CEO of OSA and The OSA Foundation</td>
<td>OSA Update</td>
</tr>
<tr>
<td>2:30 PM</td>
<td>Poster Session</td>
<td>Welcome and Institute of Optics Update</td>
</tr>
<tr>
<td>3:15 PM</td>
<td>Networking Break</td>
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<tr>
<td>3:30 PM</td>
<td>Nick Kochan, SPIE Student Chapter</td>
<td>Welcome and Institute of Optics Update</td>
</tr>
<tr>
<td>3:45 PM</td>
<td>Carlos Stroud, Professor of Optics/Physics</td>
<td>Jewel in the Crown Addendum</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Scott Carney, Professor &amp; Director, Inst Optics</td>
<td>Institute of Optics’ Covid-19 Outline, MS Program, Together for Rochester (TFR) Launch</td>
</tr>
</tbody>
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**5:00PM - 6:00PM: Networking Hour (Optional)**

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**THURSDAY, October 15, 2020: 2:00PM – 5:00PM Eastern Time**  
All held virtually via REMO.

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<th>Time</th>
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<tr>
<td>2:00 PM</td>
<td>Scott Carney, Professor &amp; Director, Inst Optics</td>
<td>Welcome and Opening Remarks</td>
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<tr>
<td>2:15 PM</td>
<td>Dr. Susana Marcos, Professor of Research at the Institute of Optics (CSIC); Director of the Visual Optics and Biophotonics Lab, and Co-Founder of ZEyesVision</td>
<td>Optical technologies in ophthalmology: from the lab to industry and into the clinic (~25 minutes + 5 Q&amp;A)</td>
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| 2:45 PM | Master’s Students Showcase      | Featuring MS students presenting educational background, work experience, and career goals.  
**Note:** They typically expect to graduate in May.  
(~2-10 minutes each) |
| 3:15 PM | Networking Break                |                                                                      |
| 3:30 PM | Graduate Students Research Talks | Featuring outstanding upper level Graduate Students presenting current project updates  
(~10 minutes each) |
| 4:30 PM | Prof. Jessica Shaw, Laboratory for Laser Energetics (LLE) | Current Research Project  
(~25 minutes + 5 Q&A) |

**5:00PM - 6:00PM: Networking Hour (Optional)**

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**FRIDAY, October 16, 2020: 11:00AM – 3:00PM Eastern Time**  
All held virtually via REMO.

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<tr>
<td>11:00 AM</td>
<td>Scott Carney, Professor &amp; Director, Inst Optics</td>
<td>Welcome and Opening Remarks</td>
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</tbody>
</table>
| 11:15 AM | Curtis Broadbent, Licensing Mgr, UR Ventures | Technology Transfer & Optics Intellectual Property Showcase Featuring Faculty IP  
(~5-10 min each) |
| 12:15 PM | Networking Break                |                                                                      |
| 12:30 PM | IA Company Introductions (A-Z Order) | IA company member representative(s) updates on contact info, open positions, interview opportunities  
(~1 minute each) |
| 1:15 PM | IA Company Showcase (Random Tables Assigned) | IA company member representative(s) + Luminate cohort companies w/student interaction for Q&A leading to formal interviews  
(~90 minutes) |

**Please note:** IA companies will be in charge of scheduling virtual interviews directly with students. See résumés for contact details.
The Industrial Associates Overview

Since 1929, The Institute of Optics has been providing industry with well-educated and trained B.S., M.S., and Ph.D. graduates. Many of these graduates go on to found important companies or to play significant roles in companies of all sizes. With approximately 3,400 Institute of Optics alumni, there is little doubt The Institute has made, and continues to make, major contributions to this country’s Optics industry. But education is only part of the story. The Institute’s faculty, staff, and students have a tradition of interacting with companies through research collaborations, consulting arrangements, in professional societies, and via a variety of other informal exchanges of ideas and information. The Industrial Associates (“IA”) Program was conceived to provide a formal framework for maintaining and nurturing this historical relationship between industry and The Institute.

Resources are required for all research and educational programs, and income derived from the IA Program plays a critical role in the operation of The Institute of Optics. In addition to covering the costs of two annual meetings, IA Program membership fees are used for important expenditures for which other sources of funds are either insufficient or unavailable. The positive impact on our educational programs of the revenue derived from the IA membership fees is enormous. Two examples are graduate student recruiting and the purchase of specialized laboratory equipment. As most of our students take positions in industry upon graduation, recruiting the best students provides very direct and tangible benefits to companies. Likewise, exposing our students to state-of-the-art laboratory instrumentation is beneficial to industry. It is no exaggeration to say that the high quality of The Institute’s graduates would Spring without a strong Industrial Associates Program.

The members of the Industrial Associates Program meet formally twice each year, usually in October and March or April. The format for each meeting is technical, featuring talks by IA member company representatives, guest speakers, faculty, graduate students and undergraduates. Luncheons with faculty, staff, and students, and an evening reception add a social dimension to each meeting. After our symposium, company representatives have a day to interview students, meet with faculty, visit research centers on the campus, or structure their day with the assistance of staff. Strategic and Select members may choose two days.

In 2014, on the 40th anniversary of the IA Program, the Director’s Advisory Council (DAC) Meeting was introduced. These meetings are conducted in a format similar to a company’s Board of Directors meeting, and they provide a formal forum for in depth discussion of The Institute’s programs with its Director, faculty and the representatives of the strategic level Industrial Associates member companies. The first Council meeting in the Fall of 2014 was primarily a review of the restructuring of the IA Program membership levels and benefits. Each DAC meeting since has provided valuable review and planning.

At our Fall 2016 Symposium, we premiered a Company Connection Showcase following input from the DAC. It was such a success that for Spring 2017 we incorporated the Company Connection Showcase in a larger venue, which we continue to feature. Our DAC members provide crucial help with ongoing ABET accreditation requirements as an external Advisory Board as they did again at the Spring 2018 and 2019 meetings. Scott Carney initiated breakout focus sessions at our Fall 2017 DAC meeting. This format engaged members in lively discussion and generated further avenues for growth. Several DAC-generated initiatives in co-ops, campus engagement, and marketing are making an impact at The Institute. This IA meeting you will see a videographer capturing some key moments and testimonials from our members and our students – another DAC-driven idea.

Finally, we are pleased to utilize Handshake as our career services platform for organizing interviews. An overview was shared during the Spring 2018 symposium along with demos. Please let us know if any additional assistance is required.

Meliora!
**IA Members & Levels**

Industrial Associate members are listed alphabetically within membership levels: Strategic, Society & Trade Associations, Select, Standard and Associate.

### STRATEGIC IA MEMBERS

<table>
<thead>
<tr>
<th>Company</th>
<th>Website</th>
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<tr>
<td>ASML</td>
<td><a href="http://www.asml.com">www.asml.com</a></td>
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<td>Corning Incorporated</td>
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<td>Danbury Mission Technologies</td>
<td><a href="http://www.dmtllc.org">www.dmtllc.org</a></td>
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<td>L3Harris Technologies (NY)</td>
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<td>Newport Corp</td>
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<td>Society, Trade, &amp; Academic Association IA Members</td>
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<td>The International Society for Optics and Photonics</td>
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<td>Safran</td>
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<td>SONY Electronics Inc.</td>
<td><a href="http://www.sony.com">www.sony.com</a></td>
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ASSOCIATE IA MEMBERS

Bristol Instruments, Incorporated
www.bristol-inst.com

Gray Optics
www.grayoptics.com

Johns Hopkins Applied Physics Lab
www.jhuapl.edu

OptoSigma Corporation
www.america.optosigma.com/

Plymouth Grating Laboratory
www.plymouthgrating.com

Spica Technologies
www.toptica.com

TOPTICA Photonics, Inc.
www.toptica.com

Wavefront Research, Inc.
www.wavefrontresearch.com
Guest Speaker

Elizabeth (Liz) Rogan
CEO, The Optical Society

OSA Update

From the political arena to Hollywood to the sciences, gender has become a predominant focus of thought leaders worldwide, but change has been incremental. Scientific societies have a responsibility to improve the participation of women in STEM fields like optics and photonics. The Optical Society along with its sister societies are making an impact by focusing on the participation of women in our programs and honors. Liz Rogan will share insights regarding OSA and its partners’ initiatives.

Liz Rogan has been at OSA for more than 20 years in positions initially focused on operations, the last position being Chief Operating Officer. Beginning in 2002, she was honored with the role of Chief Executive Officer of OSA and The OSA Foundation. As OSA CEO, she reports to the Board of Directors and is responsible for the oversight, strategic direction and fiscal soundness of programs and activities of this $40M, 150+ staff society. The OSA Foundation has a $10M+ reserve and activities include fundraising and program development. In 2016, Chad Stark became the Foundation Executive Director. In addition, Liz is the society's spokesperson and advocate to a wide range of OSA constituencies, including its members, volunteers, co-sponsors and customers, throughout the global optics community. Rogan holds a B.A. in accounting from the University of Connecticut, is a CPA, and is an alumnus of an executive business program from the Wharton School at the University of Pennsylvania.
Guest Speaker

Nicholas Kochan, PhD

Candidate in Optics and President, SPIE—Student Chapter

Industry, IA Members, and Student Connections

Nicholas Kochan is currently a PhD student working in the Moore Group at the University of Rochester. His research focuses on novel optical design and metrology methods, with a focus on gradient index optics. Kochan is currently the president of the SPIE student chapter at the University of Rochester, supporting and representing chapter efforts to create conversations in optics and participate in community outreach. In Spring 2019 he led a group of students in the creation of the first optics outreach event at the Rochester Lilac Festival, the largest free festival in Rochester. Kochan holds the BS in Optics and a Minor in Mathematics from the University of Rochester.
Carlos R. Stroud, Jr., has an AB degree in physics and mathematics from Centre College, and a PhD degree (1969) in physics from Washington University. He is currently professor of optics and professor of physics, and director of the Center for Quantum Information. He is a fellow of both the Optical Society of America and the American Physical Society. He has lectured in more than 75 different universities, held several lectureships, and since 1998 is a distinguished traveling lecturer for the Division of Laser Science of the American Physical Society.

Recent Publications
"A Jewel in the Crown" - A compilation of essays in chronicling the first seventy-five years of the history of the Institute of Optics. For a list of Dr. Stroud's scientific publications, click here.

Research Overview
His research interests range over most of theoretical and experimental quantum optics. Among the research accomplishments of his group are the first observation of the modification of the spectrum of spontaneous emission by a resonant laser beam, and early observations of various phenomena in three-level atomic systems driven simultaneously by two resonant laser fields including the Autler-Townes effect and coherent population trapping. More recently his group made the first observation of a spatially localized electron wave packet within an atom, and is working on production of quantum states of light and on quantum information.
Susana Marcos is a MsC (1992) and PhD (1996) in Physics from the University of Salamanca and was a postdoctoral researcher (1997-2000) at Harvard University, with a Fulbright and Human Frontiers Science scholarships. She has been Director of the Institute of Optics, CSIC (2008-2012) and Director at Large of the Optical Society of America. She is currently a Professor of Research and Director of the Laboratory of Visual and Biophotonics Optics at the Institute of Optics, CSIC, where she supervises a multidisciplinary (physicists, biomedical, telecommunications, materials, mechanical engineers, chemists and vision scientists) international team of >25 members. Susana Marcos is a pioneer in the development of new techniques for the evaluation of the eye, including retinal imaging instruments, aberrometers, adaptive optics, anterior segment imaging of the eye and intraocular lens designs.

Several of these technologies (QuickseeTM, SimVisTM and Isofocal IOL) have been marketed and contributed to improving the diagnosis and treatment of thousands of patients. She has published more than 180 highly cited research articles, is the inventor of 20 patent families (14 licensed to the industry), is co-founder of the Plenoptika and 2EyesVision spin-offs, has directed 18 doctoral theses and presented more than 200 talks at international conferences and conferences. Public and private projects led by Susana Marcos in the last ten years have exceeded 10 million euros in funding (2 ERC Advanced Grant, H2020-ICT Innovation Action, 3 ERC Proof of Concept Grants, 2 ITN-Marie Skłodowska-Curie Actions and dozens of contracts with international companies in the ophthalmic sector). She has served in various positions at the Optical Society of America, Spanish Society of Optics, Association for Research in Vision and Ophthalmology, MIT M + Vision Consortium and as editor in Vision Research, Biomedical Optics Express, Optica, among others.

Susana is currently the President of the Technical Scientific Committee of the National Research Agency, and is a member of the Scientific Advisory Council of the Gadea Science Foundation and the CSIC General Foundation, Alcon Research Institute, Advisory Council of the Generalitat of Valencia, and a Member Publication Council of the Optical Society. Recognitions include the Adolph Lomb Medal (Optical Society of America), ICO Prize (International Commission for Optics), Doctor Honoris Causa by the Ukraine Academy of Science and Technology, OSA Fellow, EOS Fellow, ARVO Fellow, Alcon Research Institute Award, Borish Scholar Award (Indiana University), Physics, Innovation and Technology Award (Royal Spanish Society of Physics-BBVA Foundation), Honor Plate of the Spanish Association of Scientists, King Jaime I Award, Ramón y Cajal Medal (Royal Academy of Sciences), and National Research Award in Engineering (Government of Spain).
**Guest Speaker**

Dr. Jessica Shaw  
*LLE—Laboratory for Laser Energetics*  
Email: jessica.shaw@rochester.edu

**Spatiotemporal Pulse Shaping**

Jessica Shaw is a scientist in the Plasma and Ultrafast Physics Group at the University of Rochester’s Laboratory for Laser Energetics. Her research focuses on Raman Amplification of laser pulses and laser-plasma accelerators, with an emphasis on applying spatiotemporal pulse shaping to new laser-plasma accelerator concepts.
Curtis Broadbent is an assistant professor (part-time) in the Department of Physics and Astronomy at the University of Rochester. He was most recently a post-doctoral research associate in Joe Eberly's research group in theoretical quantum optics (Eberly Research Group), also at the University of Rochester. He is currently investigating non-Markovian effects in open quantum systems, measures of genuinely multipartite entanglement, entropic steering inequalities, quantum state discrimination, long-distance quantum key distribution, and weak measurements.

Curtis graduated in August of 2010 from John Howell's experimental quantum optics research group (Howell Research Group) in the Department of Physics and Astronomy. While in John's group, he worked on projects related to quantum image discrimination, slow light with entangled photons and pseudo-thermal light, and applications of bipartite photonic entanglement to quantum cryptography. Additionally, he collaborated with Andrew Jordan's research group (Jordan Research Group) on an experimental and theoretical investigation into non-local weak-value measurements.

Curtis completed his undergraduate degree at Brigham Young University with a B.S. in Physics in 2003. At Brigham Young University, he worked with Scott Glasgow and Justin Peatross on dynamical notions of energy loss and irreversibility in phenomenologically modeled dielectric/field systems.
**Poster Session**

Each Industrial Associates meeting features a kaleidoscope of posters providing a seasonal glimpse into the research projects of The Institute of Optics. Members and attendees will find posters on display in the Wilson Commons | Bridge Lounge during the lunch break.

Arnab Barman Ray  
Xue Dong  
Ruiting Huang  
Arjun Iyer  

David Lippman  
Nick Kochan  
MS Co-op Information Table

**Graduate Students Showcase & Research Talks**

This part of the program features presentations by candidates for Master’s and Ph.D. Degrees and will speak to their experience, research/abstract topics, and other highlights.

**MS Showcase**

MS Students seeking internships & post-graduation employment

---

**Saniat Ahmed Choudhury**

**Education Highlights**
- MS in Optics (Dec 2020), MS in EE, BS in EE, Experienced with Lumerical's FDTD, DEVICE, COMSOL, Lasers, Material processing

**Work Experience**
- Researcher under Dr. John Marcian, worked with high-power ultrafast lasers and material surface processing

**Objectives**
- To work in a research-driven optics research position  
- To learn and face challenges in the industry head-on.
MS Showcase (Continued)

MS Students seeking internships & post-graduation employment

Jiwon Jung

Education Highlights
University of Rochester
- B.S. Optical Engineering, May 2020
- M.S. Optics, Expected May 2021

Work Experience
- Apple [June-Aug 2020]: sequential and non-sequential raytracing (Zemax) and optical analysis of a display test station
- General Atomics Electromagnetic Systems [June-Aug 2018]: analyzed various imaging systems and performance through Zemax and lab set-ups
- Advanced Physiological Optics Lab (Yoon Lab) [Feb 2019 – Feb 2020]: studied Purkinje reflections for applications in binocular eye tracking. Experience with optical assembly, components, and alignment.

Objectives
- Seeking full-time position following May 2021 graduation
- Primary Interests: optical design, imaging systems, R&D

Alen Philip

Education Highlights
- Pursuing master’s degree from the Institute of Optics
- BS-MS in Physics from Indian Institute of Science Education and Research, Bhopal

Work Experience
- MS thesis project in 3D Visualization of Folded Optical Systems in AR/VR (Ongoing)
- MS thesis project in Study of Nitrogen-vacancy Defects in Diamond
- Material science internships

Technical Strengths
- Proficient in multiple programming languages and data handling software tools
- Proficient in CodeV

Objectives
- Seeking a full-time position post graduation (May 2021)

Relevant Courses
MS Showcase (Continued)

MS Students seeking internships & post-graduation employment

Huaze Xie

Education Highlights
Current: University of Rochester, MS in Optics
Undergraduate: Taizhou Institute of Sciences & Technology, NUST
Major: Electric Engineering and Automation

Work Experience
Internship: Optical design for lens of CCTV via optical design software Zemax in R&D department
Phenix optic Co., Ltd in China Hangzhou (05/15/2020-now)
Intern: Learned the structure of molds and the design and assemblage of precision molding equipments
Daeho Technology Co., Ltd in Korea (01/13/2018-01/25/2018)

Objectives
- Designing lens / Fabrication for Optic Communication chips
- Optical design area for lens used for cars or CCTV or factory control system. / Some Optical communication instruments' manufacturer like chips.

MS Research Presentation

Topic: Phase shifting interferometry of refractive index microstructures in hydrogels

Yiyang Wu

Education Highlights
- MS 2021
- Lens design, metrology, illumination, coating, color, waveguide

Work Experience
- Optical engineer intern on AR glass at Kura Tech.
- Researcher on phase shifting interferometry of refractive index microstructure by femtosecond laser micromachining at UR

Objectives
- A full-time position needs a competitive optics person
MS Showcase (Continued)

MS Co-op Students seeking Co-op starting Winter/Spring 2021

Alex Davie

Emma Foley

Education Highlights
University of Rochester
- M.S. in Optics – Expected May ’22
  - Specializing in optical design, fabrication, and testing
- B.S. in Biomedical Engineering, High Honors – May ’20
  - Concentration in medical optics

Work Experience
- Collins Aerospace | Optical Engineering Intern; Fall Co-Op (Jun ’20 – Current)
  - Optical design/analysis - deep space optics
  - Stray light test device design, assembly, alignment, and operation
- Clerio Vision, Inc | R&D Engineering Intern (Jun – Aug ’19)
  - Femtosecond laser system alignment and optimization
  - Precision metrology, tissue handling, experimental test design
- Center for Visual Science, Hunter Lab | Research Assistant (Dec ’17 – May ’19)
  - Advanced biomedical imaging (two-photon adaptive optics fluorescence lifetime ophthalmoscopy)
  - Image processing, statistical analysis, vision science

Objectives
- Seeking careers in optical design, fabrication, or testing in any field of optics
- Open to Co-op positions starting January 2021
MS Showcase (Continued)

MS Co-op Students seeking Co-op starting Winter/Spring 2021

John Gilmore

Ashley Pruett

Education Highlights
B.S. Physics at Missouri S&T
Minor in Mathematics
M.S. Optics at University of Rochester

Work Experience
- Measured the noise floor of a Michaelson Interferometer

Objectives
- I am open to a Co-Op of any kind
MS Showcase (Continued)

MS Co-op Students seeking Co-op starting Winter/Spring 2021

Kaibo Zhang

Education Highlights
- Master of Optics
- Bachelor of Electrical and Computer Engineering

Work Experience
- Research on the simulation of electromagnetism and data analysis using ANSYS and MATLAB

Objectives
Seeking a co-op position within the field of optical communication
**PhD Research Talks**

**Nick Takaki**  
Advisor: Prof. Jannick Rolland-Thompson  
Freeform Optics: Design-for-manufacture via orthogonal polynomials

**Ruiting Huang**  
Advisor: Prof. Wayne Knox  
Enhanced efficacy in refractive index modifications of rabbit eye globe ex-vivo with low repetition rate blue femtosecond laser pulses

**Tianyi Yang**  
Advisor: Prof. Duncan Moore  
Freeform GRIN: new variables in GRIN design
PhD Research Talks (Continued)

Ashan Ariyawansa Galabada Dewage
Advisor: Prof. Thomas Brown
Amplitude and phase sorting of orbital angular momentum modes at low light levels

Di Xu
Advisor: Prof. Jannick Rolland
Cascade optical coherence tomography (C-OCT) towards freeform metrology
The Institute of Optics Overview

It is the fate of higher education to be in a state of endless evolution. Prior to approximately 1850, colleges in the U.S. focused for the most part on the classical curriculum: ancient languages, mathematics, natural philosophy, chemistry, and moral philosophy. Over time, more specialized and practical degree programs such as business, education, science, and engineering were developed to meet the needs of a changing world. In science, the University of Rochester was an early innovator, being one of the first institutions in the U.S. to form science departments and to award the degree Bachelor of Science. One particularly prominent Rochester innovation was the founding in 1929 of The Institute of Applied Optics, the name of which was shortened in 1939 to The Institute of Optics. Now, more than six decades later, the boldness and wisdom of that move were never clearer. Who could have foreseen in 1929, more than thirty years before the demonstration of the first laser and more than forty years before the demonstration of the low-loss optical fiber, the rich and vibrant field that optical science and engineering would become!

Today, The Institute of Optics is the preeminent program of higher education in Optics in the United States. The first such program in the U.S., The Institute granted the nation’s first B.S. degree in Optics to Arthur Ingalls in 1932, the first M.S. degree in Optics to Perley Nutting, Jr. in 1938, and the first Ph.D. in Optics to Wayne McKusick in 1940. Originally a stand-alone academic unit of the University of Rochester, The Institute is now an internationally recognized academic department within the university’s Hajim School of Engineering and Applied Science.

Former Directors include several OSA Presidents, two university Provosts and a Director of the White House Office of Technology Policy. Other faculty and former faculty occupy similar prominent positions in professional societies, industry and the optics community in general.

The Institute of Optics features a distinguished interdisciplinary faculty made up of physicists, applied physicists, materials scientists and engineers, and a student body consisting of 170+ undergraduate majors pursuing the B.S. degree in Optics and 125+ graduate students pursuing the M.S. or Ph.D. in Optics. The early history of The Institute of Optics is graced with the names of such prominent Rochesterians as George Eastman, Edward Bausch, Rudolf and Hilda Kingslake, and Brian O’Brien. In later years, such men as Robert Hopkins and Brian Thompson helped advance The Institute’s reputation.

The size of The Institute’s faculty currently stands at 18 professors with full-time appointments; 13 professors with secondary Optics appointments from diverse departments such as imaging sciences, physics, dermatology, electrical and computer engineering, Laboratory for Laser Energetics, and chemistry; 11 adjunct professors and lecturers, 2 senior scientists; 20+ professional personnel, including research scientists, and post-doctoral scientists, etc.; and 8 full time staff members.

Optics is defined very broadly at Rochester, ensuring that students can select from a broad range of research fields. The faculty maintain research programs in laser physics and engineering, optical system design, optical detector, semiconductor lasers, electronic imaging, diffractive optics, fiber optics, nonlinear optics, quantum optics, optical materials, guided-wave optics and optoelectronics, theoretical foundations of optics, ultrafast phenomena, gradient-index optics, the precision manufacturing of optical elements, applications of holography, wave propagation, medical optics, image processing and wave front sensing, high-intensity laser-matter interactions, nano-optics, and biomedical optical systems, optical instrumentation, and system engineering.
After completing the degree, Ph.D. graduates of The Institute of Optics take positions in large and small companies, on the faculties of research universities and liberal arts colleges, and in federal laboratories.

At Rochester, The Institute of Optics strikes a balance between engineering and basic science. In teaching and research, the Optics program spans the continuum between the fundamental and the applied. Students intending to do very basic research are nevertheless required to understand such practical matters as radiometry and aberrations in lenses. Students intending to do more applied research are likewise required to take courses of a fundamental nature. The objective is to produce graduates who not only are broadly educated in the field of optics, but also respect the importance of the full spectrum of subfields.

The most serious issues facing graduate education in optics today are no different than those facing graduate education in science and engineering in general. One serious challenge is to maintain the willingness of young men and women to pursue technical graduate degrees of any sort. Another is to make sure that our citizens understand the importance of research in modern society. As a field, optical science and engineering can hold its own. It is an interesting, challenging, relevant, and intimate field, one in which it is still possible to do important work in a setting of modest size. Communicating to the general public that its future standard of living, and that of its children, depends in a very real way on today's investments in research is as important now as it has ever been. If that challenge can be met, then the future of optical science and engineering will be a bright one.
Undergraduate Course of Study

The Institute of Optics is a distinct academic department, originally established in 1929 for undergraduate education in optical science and engineering. While we at the Institute incorporate much more research and graduate education into our activities than was the case in the early 20th century, undergraduate education remains a central focus. Because of the substantial overlap between optics, mathematics, and physics, many students opt for either a minor or a double major in one of the other disciplines. By choosing appropriate technical electives, and a design project, students can complete a degree in optical engineering. Students with an interest in fundamental applied optics may opt for a senior thesis and qualify for a degree in optics.

The basic elements of this demanding degree are outlined below. The required optics courses are carefully designed to span the most significant areas in classical and modern optics. In addition, three technical electives are required, which allow students to tackle a specialty such as lens design, electron microscopy, thin films, or any course selected from the MS curriculum. Undergraduates are encouraged to gain technical experience through paid laboratory assistantships, summer research (e.g. REU) programs, industrial employment and internships, and senior-level honors research.

With a history of more than 75 years and more than three thousand graduates, the optics B.S. program is well-recognized by the optics industry and is well-established as a high-quality undergraduate department. The career choices of our undergraduates include advanced degree work leading to MS-level optical design and engineering, doctoral research leading to teaching, research, and corporate leadership, technical support and marketing, patent law, business management and a host of entrepreneurial activity.
The B.S. degree in Optics (OPT) or Optical Engineering (OE) consists of a minimum of 130 credit hours of coursework. Required courses are noted with “(req.)” in the table on the next page. Please note: The first three years are virtually identical for students pursuing either degree (all courses carry 4 credits unless otherwise indicated). The course requirements are applicable for the Class of 2021. Changes will affect students in the Class of 2020 and beyond as described on the website.

A description of all Optics courses may be found on the Optics webpage:
http://www.optics.rochester.edu/undergraduate/courses.html

Undergraduate Course of Study – Class of 2020 and Beyond

<table>
<thead>
<tr>
<th>Year</th>
<th>Fall Courses</th>
<th>Spring Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>MTH 161 Calculus I</td>
<td>MTH 162 Calculus II</td>
</tr>
<tr>
<td></td>
<td>CHM 131 Chemistry for Engineers</td>
<td>PHY 121 Mechanics</td>
</tr>
<tr>
<td></td>
<td>WRT 105* College Writing or Cluster Course #1 (required)</td>
<td>WRT 105* College Writing or Cluster Course #1</td>
</tr>
<tr>
<td></td>
<td>OPT 101 Introduction to Optics (recommended)</td>
<td>OPT 211 MATLAB for Optics Majors I (2cr.)</td>
</tr>
<tr>
<td>~30 Credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 2:</td>
<td>OPT 241 Geometrical Optics</td>
<td>OPT 261 Interference &amp; Diffraction</td>
</tr>
<tr>
<td>Sophomore</td>
<td>OPT 201 Geometrical Optics Lab (2cr.)</td>
<td>OPT 202 Physical Optics Lab (2cr.)</td>
</tr>
<tr>
<td>~36 Credits</td>
<td>MTH 164 Multidimensional Calculus</td>
<td>OPT 287 Math Methods for Optics and Physics</td>
</tr>
<tr>
<td></td>
<td>PHY 122 Electricity and Magnetism</td>
<td>PHY 123 Waves and Modern Physics</td>
</tr>
<tr>
<td></td>
<td>Cluster course or tech elective</td>
<td>Cluster course or tech elective</td>
</tr>
<tr>
<td>Year 3:</td>
<td>OPT 242 Aberrations &amp; Testing</td>
<td></td>
</tr>
<tr>
<td>Junior</td>
<td>OPT 203 Aberrations &amp; Testing Lab (2 cr.)</td>
<td></td>
</tr>
<tr>
<td>~32 Credits</td>
<td>OPT 262 Electromagnetic Theory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTH 165 Linear Algebra w/ Diff. Equations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OPT 212 MATLAB for Optics Majors II (2cr.)</td>
<td></td>
</tr>
<tr>
<td>Year 4:</td>
<td>B.S. in Optics (OPT)</td>
<td>B.S. in Optics (OPT)</td>
</tr>
<tr>
<td>Senior</td>
<td>OPT 320 Senior Thesis I</td>
<td>OPT 321 Senior Thesis II</td>
</tr>
<tr>
<td>~32 Credits</td>
<td>Cluster, Tech, or free elective x 3</td>
<td>Cluster, Tech, or free elective x 3</td>
</tr>
<tr>
<td></td>
<td>B.S. in Optics (OE)</td>
<td>B.S. in Optics (OE)</td>
</tr>
<tr>
<td></td>
<td>OPT 310 Senior Design I</td>
<td>OPT 311 Senior Design II</td>
</tr>
<tr>
<td></td>
<td>Cluster, tech, or free elective x 3</td>
<td>Cluster, tech, or free elective x 3</td>
</tr>
</tbody>
</table>

*Students not enrolled in WRT 105 in the Fall should take cluster course #1. Students enrolled in WRT 105 in the Fall should take cluster course #1 in the Spring.

**Note:** Students may elect to take 16 credits during Freshman Spring semester (16 credit minimum is required to be eligible for Dean’s List).
There are three basic ways to earn the M.S. degree. The first involves completing six graduate-level Optics courses and a thesis, a program that typically requires two years to complete. The second requires completing eight courses and writing a paper based on literature research, a program that can be completed in a single year. The third, also a non-thesis option, is an M.S. Co-Op program, in which a one-year work-period in industry is inserted between the two required semesters of coursework, making it a two-year program overall. Between 1988 and 2020, The Institute placed 91 M.S. students in one-year Co-Op slots in 23 companies.

A typical set of courses taken by students enrolled in either of the non-thesis M.S. options appears in the table below. Four of the eight courses are required (req.), the remaining four are electives. Examples of alternative choices are Optical Thin Film Coatings, Guided-Wave Optics, Biomedical Optics, and Lens Design, among others. Another version of the non-thesis route allows the M.S. student more opportunity to concentrate in a specific sub-field of Optics.

Interest in the M.S. degree program remains high among both students and employers. The typical M.S. applicant holds a B.S. degree in Physics, Electrical Engineering, or Optics, but it is not uncommon for those holding M.S. degrees in Physics or Electrical Engineering, or even doctorates in allied fields, to apply for admission to the Optics M.S. program. In recent years, The Institute has admitted M.S. applicants holding Ph.D.’s in Physics from MIT, Stanford, and Purdue, and one with a Ph.D. in Physical Chemistry from Johns Hopkins. No matter what a student’s educational background is, the M.S. Degree in Optics is a professional credential that identifies the graduate as a bona fide optical engineer.

<table>
<thead>
<tr>
<th>Fall Courses</th>
<th>Spring Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave Optics and Imaging (req.)</td>
<td>Detection of Optical Radiation (req.)</td>
</tr>
<tr>
<td>Foundations of Modern Optics (req.)</td>
<td>Optics Laboratory (req.) or Elective</td>
</tr>
<tr>
<td>Optics Laboratory (req.) or Elective</td>
<td>Elective</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>

Optics is defined very broadly at Rochester, ensuring that students can select from a broad range of research fields. The faculty maintain research programs in laser physics and engineering, optical system design, optical detector, semiconductor lasers, electronic imaging, diffractive optics, fiber optics, nonlinear optics, quantum optics, optical materials, guided-wave optics and optoelectronics, theoretical foundations of optics, ultrafast phenomena, gradient-index optics, the precision manufacturing of optical elements, applications of holography, wave propagation, medical optics, image processing and wave front sensing, high-intensity laser-matter interactions, nano-optics, and biomedical optical systems, optical instrumentation, and system engineering.
The Institute of Optics has separate admissions processes for the M.S. and Ph.D. programs; admission to the M.S. program does not confer admission to the Ph.D. program, nor is the M.S. required to earn the Ph.D. For the last fifteen years, The Institute has enrolled approximately 16 Ph.D. students each year from a pool of applicants that numbers in the hundreds. In any given year 55 – 65% of the students admitted are U.S. citizens.

Ph.D. students take a common set of seven core courses, plus one elective in their first year (except in cases where a student’s previous coursework argues for a change).

<table>
<thead>
<tr>
<th>Year 1: Fall Courses</th>
<th>Year 1: Spring Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Optics (Fourier Optics) (req.)</td>
<td>Electromagnetic Theory (req.)</td>
</tr>
<tr>
<td>Geometrical Optics (req.)</td>
<td>Instrumental Optics (req.)</td>
</tr>
<tr>
<td>Radiation and Detectors (req.)</td>
<td>Quantum Mechanics (req.)</td>
</tr>
<tr>
<td>Mathematical Methods (req.)</td>
<td>Fundamentals of Lasers</td>
</tr>
</tbody>
</table>

Second-year Ph.D. students combine more specialized courses that aim to prepare them for research with two semesters of service as teaching assistants (mandatory). Any remaining courses are taken in the third year, but most of the third year and beyond is devoted to research. The time required to complete the Ph.D. depends on the student’s interaction with his or her adviser and thesis committee. With their guidance, the student is assured of steady progress and beneficial advice.

<table>
<thead>
<tr>
<th>Year 2/3: Fall Courses</th>
<th>Year 2/3: Spring Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantum Electronics I, II Nano-Optics</td>
<td>Lens Design Medical Imaging</td>
</tr>
<tr>
<td>Advanced Lens Design Optical</td>
<td>Optical Properties of Materials</td>
</tr>
<tr>
<td>Communications Optical Fabrication &amp; Testing Biomedical Optics</td>
<td>Principles of Eye Design</td>
</tr>
<tr>
<td>Electronic Imaging Systems</td>
<td>Quantum Optics</td>
</tr>
<tr>
<td>Waveguide Optoelectronic Devices</td>
<td>Optics Laboratory Advanced</td>
</tr>
<tr>
<td>Optical Interference Coatings</td>
<td>Optical Coatings Polarization</td>
</tr>
<tr>
<td>Nonlinear Optics</td>
<td>Technical Entrepreneurship</td>
</tr>
</tbody>
</table>
Doctoral Program Course of Study (Cont’d)

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The subsequent pages list each faculty member alphabetically with his or her contact information and website (as available). *Click on name for short biography and research overview / abstract.*

**Agrawal, Govind P.**  
*James C. Wyant Professor of Optics  
Professor of Physics  
Senior Scientist, LLE*  
gpa@optics.rochester.edu | (585) 275-4846  
515 Goergen Hall  
Website  
**Interests:** Fiber Optics; Lasers; Optical Communications

**Alonso, Miguel A.**  
*Professor of Optics*  
alonso@optics.rochester.edu | (585) 275-7227  
213 Wilmot Building  
Website  
**Interests:** Mathematical Models of Wave Propagation

**Bentley, Julie**  
*Associate Professor of Optics*  
bentley@optics.rochester.edu | (585) 273-1687  
407 Goergen Hall  
**Interests:** Optical Design; Engineering

**Berger, Andrew J.**  
*Professor of Optics  
Associate Professor of Biomedical Engineering*  
ajberger@optics.rochester.edu | (585) 273-4724  
405 Goergen Hall  
Website  
**Interests:** Biomedical Optics; Optics Education
Bigelow, Nicholas P.
Lee A. DuBridge Professor of Physics
Professor of Optics
nbig@lle.rochester.edu | (585) 275-8549
312 Bausch & Lomb Building
Website

**Interests:** Quantum Optics; Quantum Physics

Boyd, Robert
Professor of Optics
Professor of Physics
boyd@optics.rochester.edu | (585) 275-2329
308 Wilmot Building
Website

**Interests:** Nonlinear Optics

Bromage, Jake
Associate Professor of Optics
Senior Scientist and Group Leader, Laser Technology Development, LLE
jbro@lle.rochester.edu | (585) 273-5105
270A LLE—Laboratory for Laser Energetics

**Interests:** Ultrafast and ultra-intense lasers, optical parametric amplification, and laser diagnostics

Brown, Thomas G.
Professor of Optics
brown@optics.rochester.edu | (585) 275-7816
516 Goergen Hall

**Interests:** Optoelectronics

Cardenas, Jaime
Assistant Professor of Optics
jaime.cardenas@rochester.edu | (585) 275-7320
226 Wilmot Building
Website

**Interests:** Nanophotonics; Integrated Photonics; Biophotonics; Lasers; Nonlinear Photonics
Carney, Scott  
*Professor of Optics*  
*Director of the Institute of Optics*  
[scott.carney@rochester.edu](mailto:scott.carney@rochester.edu) | (585) 274-0113  
113 Wilmot Building  

**Interests:** Computed Imaging; Spectroscopy; Coherence Theory

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Eberly, Joseph H.  
*Andrew Carnegie Professor of Physics*  
*Professor of Optics*  
[eberly@pas.rochester.edu](mailto:eberly@pas.rochester.edu) | (585) 275-4351  
321 Bausch & Lomb Building  

**Interests:** Quantum Optics

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Fienup, James R.  
*Robert E. Hopkins Professor of Optics*  
*Professor of Electrical and Computer Engineering*  
*Professor in the Center for Visual Science*  
[fienup@optics.rochester.edu](mailto:fienup@optics.rochester.edu) | (585) 275-8009  
410 Wilmot Building  
[Website](https://www.rochester.edu/physics/optics/faculty/fienup/)

**Interests:** Image Reconstruction; Wavefront Sensing

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Foster, Thomas  
*Professor of Imaging Sciences*  
*Professor of Optics*  
*Professor of Physics*  
*Professor of Biomedical Engineering*  
[thomas.foster@rochester.edu](mailto:thomas.foster@rochester.edu) | (585) 275-1347  
3-5333 Medical Center  
[Website](https://www.rochester.edu/medicine/centers/biomedical-faculty/thomas-foster/)

**Interests:** Medical Optics; Photodynamic Therapy
George, Nicholas
Emeritus Professor of Optics
nicholas.george@rochester.edu
Website

Interests: Physical Optics; Imaging

Guo, Chunlei
Professor of Optics
guo@optics.rochester.edu | (585) 275-2134
419 Wilmot Building
Website

Interests: Laser-Matter Interactions; Ultrafast Phenomena; Surface Functionalization; Atomic & Molecular Physics

Hunter, Jennifer
Assistant Professor, Department of Ophthalmology
Assistant Professor, Department of Biomedical Engineering
Assistant Professor, Center for Visual Science A&S
Assistant Professor, The Institute of Optics
jhunter@UR.Rochester.edu | (585) 273-4935
G4111 School of Medicine and Dentistry
Website

Interests: Retinal damage; Retinal imaging

Huxlin, Krystel
James V. Aquavella, MD Professorship in Ophthalmology
Director of Research, Department of Ophthalmology
Professor of Ophthalmology
Professor of Brain/Cognitive Sciences
Professor of Visual Science
Professor of Neuroscience
Professor of Optics
khuxlin@ur.rochester.edu | (585) 275-5495
G3186 School of Medicine and Dentistry
Website

Interests: Physiological Optics; Laser Vision Correction; Visual Neuroscience and Perception; Clinical Applications
Knox, Wayne H.

Professor of Optics
Professor of Physics
Professor of Visual Sciences
Professor of Materials Science
wknox@optics.rochester.edu | (585) 273-5520
507 Goergen Hall
Website

Krauss, Todd D.

Professor of Chemistry
Professor of Optics
Chair, Chemistry Department
krauss@chem.rochester.edu | (585) 275-5093
465 Hutchinson Hall
Website

Interests: Optics of nanoscale semiconductor materials; Quantum optics and nanoscience

Kruschwitz, Brian

Associate Professor of Optics
Senior Scientist, LLE
bkru@lle.rochester.edu | (585) 273-5104
LLE—Laboratory for Laser Energetics

Interests: High energy and high power laser systems; Optical systems; Adaptive optics; Laser diagnostics

Kruschwitz, Jennifer D. T.

Assistant Professor of Optics
jennifer.kruschwitz@rochester.edu | (585) 276-7823
509 Wilmot Building

Interests: Optical Interference Coatings and Color
Lin, Qiang
Associate Professor of Optics and Electrical and Computer Engineering
qiang.lin@rochester.edu | (585) 275-3799
342 Hopeman Building
Website

**Interests:** Nanophotonic Devices; Physics and Applications

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Marciante, John
Associate Professor of Optics
marciante@optics.rochester.edu | (585) 273-4737
514 Goergen Hall
Website

**Interests:** Lasers; Waveguides; Fiber Optics; Ultrafast

---

Miller, Benjamin L.
Dean’s Professor of Dermatology
Professor of Biomedical Engineering
Professor of Optics
Professor of Biochemistry and Biophysics
benjamin_miller@urmc.rochester.edu | (585) 275-9085
5-6141A Medical Center
Website

**Interests:** Optical Biosensing and Integrated Photonics

---

Moore, Duncan T.
Rudolf and Hilda Kingslake Professor in Optical Engineering Science
Professor of Optics
Professor of Biomedical Engineering
Professor of Business Administration in the William E. Simon Graduate School of Business Administration
moore@optics.rochester.edu | (585) 275-5248
409A Goergen Hall
Website

**Interests:** Optical Engineering; Lens Design & Manufacturing; Gradient-Index Optics
Oliver, James
Associate Professor
Scientist, LLE
joli@lle.rochester.edu | (585) 275-1194
LLE—Laboratory for Laser Energetics

Renninger, William
Assistant Professor of Optics
william.renninger@rochester.edu | (585) 276-3709
214 Wilmot Building
Website

**Interests:** Experimental Nonlinear Optics

Rolland, Jannick
Brian J. Thompson Professor of Optical Engineering
Professor of Optics and Biomedical Engineering
Professor in the Center for Visual Science
Director, NSF/IUCRC: Center for Freeform Optics
Director, R.E. Hopkins Center for Optical Design & Engineering
rolland@optics.rochester.edu | (585) 752-1013
505 Goergen Hall
Website

**Interests:** Optical System Design; Instrumentation and System Engineering; Optical Coherence Tomography; Head Worn Displays

Schmidt, Greg
Assistant Professor of Optics
greg.schmidt@rochester.edu | (585) 275-8012
408 Goergen Hall
**Stroud, Carlos R., Jr.**  
*Professor of Optics*  
*Professor of Physics*  
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**Interests:** Quantum Optics

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Graduate Students
View list of graduate students and contact information here:

http://www.hajim.rochester.edu/optics/gradstudents/index.html
Institute Staff

This section lists each staff member alphabetically with his or her area or responsibility and contact information.

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Professional Organizations: Student Chapters

**SPIE**

SPIE is the International Society for Optics and Photonics. The University of Rochester Student Chapter was established in 2009 and has since grown to be the largest student chapter in North America, with over 80 registered student and alumni chapter members. We promote optical science and engineering while supporting the professional development of our chapter members. To accomplish this, we regularly teach and display optical technologies to members of the Rochester community, invite speakers to visit with students on campus, and schedule tours of local optics companies.

**Current Officers:**

- **President:** Nick Kochan
- **Vice President:** Nick Takaki
- **Secretary:** Katie Dunn
- **Treasurer:** Romita Chaudhuri
- **Web Administrator:** Saniat Choudhury
- **Communications Officer:** Ben Moon
- **Outreach Chair:** Saleem Iqbal

If you would like to host a company tour or collaborate with us on outreach or professional development events, please contact urspie@gmail.com.

**OSA**

The University of Rochester's Optical Society (OSA) Student Chapter is a pre-professional organization and academic club. Our mission is to promote and advance the science of light amongst the student body of the University of Rochester. One of our largest goals each year is to provide students with professional development workshops aimed at giving them the skills they need to succeed. As our events this semester have been hosted virtually, we have been working to find creative ways to engage with and teach optics to the campus and community at large, as well as host virtual social events to promote interaction between students to supplement what they are not getting in person this semester. Our biggest event of the year, bringing together Institute undergraduates, graduates, and faculty, is our annual Photon Cup soccer match with the Physics department. While last year's game was canceled, we are optimistic about returning to defend our title as champions this spring.

**Current Officers:**

- **President:** Benjamin Nussbaum
- **Professional Development Chair:** Cherine Ghazouani
- **Social Chair:** Madelyn Sabatini
- **Outreach Chair:** Icel Sukovaty
- **Secretary:** Dwight Fairchild
- **Business Manager:** Anand Idris

Please contact Benjamin Nussbaum at bnussbau@u.rochester.edu with any questions, comments, or ideas.
Optics Summer Short-Course Series
June 2021

In 2020, The Institute of Optics offered its 59th and first virtual annual Summer Short-Course Series with a mix of a courses and virtual course times. Course dates for 2021 are under review. The courses listed below will most likely be offered again along with a few new courses. For updates and details in 2021, please continue to monitor updates at: http://www.hajim.rochester.edu/optics/summer/registration.html.

**Applied Concepts**—colorimetry and vision, wave guide photonics, and more.

**Fundamental Concepts**—covering lenses, aberrations, principles of diffraction, optical systems, polarization, birefringence and crystal optics, and radiometry and detection.

**Integrated Photonics Circuits**—targeted for students, researchers, and engineers in industry, who want to learn the fundamental aspects of integrated photonics circuits.

**Introduction to Computational Imaging and Information Essentials**—introduces computational imaging, a modern paradigm in imaging in which the burden of image formation is no longer borne solely by optical physics.

**Modern Optical Engineering**—covering optical testing and instrumentation, optical manufacturing, optical thin film coatings, diffractive optics, and glass in modern optics.

**Optical System Design**—introduces participants to both fundamental and advanced concepts in optical system design by integrating classroom lectures with software training labs. The course can be taken as a full week course or as one of two three-day course options depending on interest/skill level. *Introduction to Optical System Design* covers first order layout, image quality evaluation, aberration theory, optimization, and refractive/reflective design forms. *Advanced topics in optical system design* begins with refractive/reflective design forms and then covers advanced optimization techniques, zoom lenses, aspheres, stray light analysis, tolerancing, and illumination design.

**Optical Thin Film Coating Technology**—covers all aspects of optical interference devices including thin-film design, digital design methods, and coating and characterization.