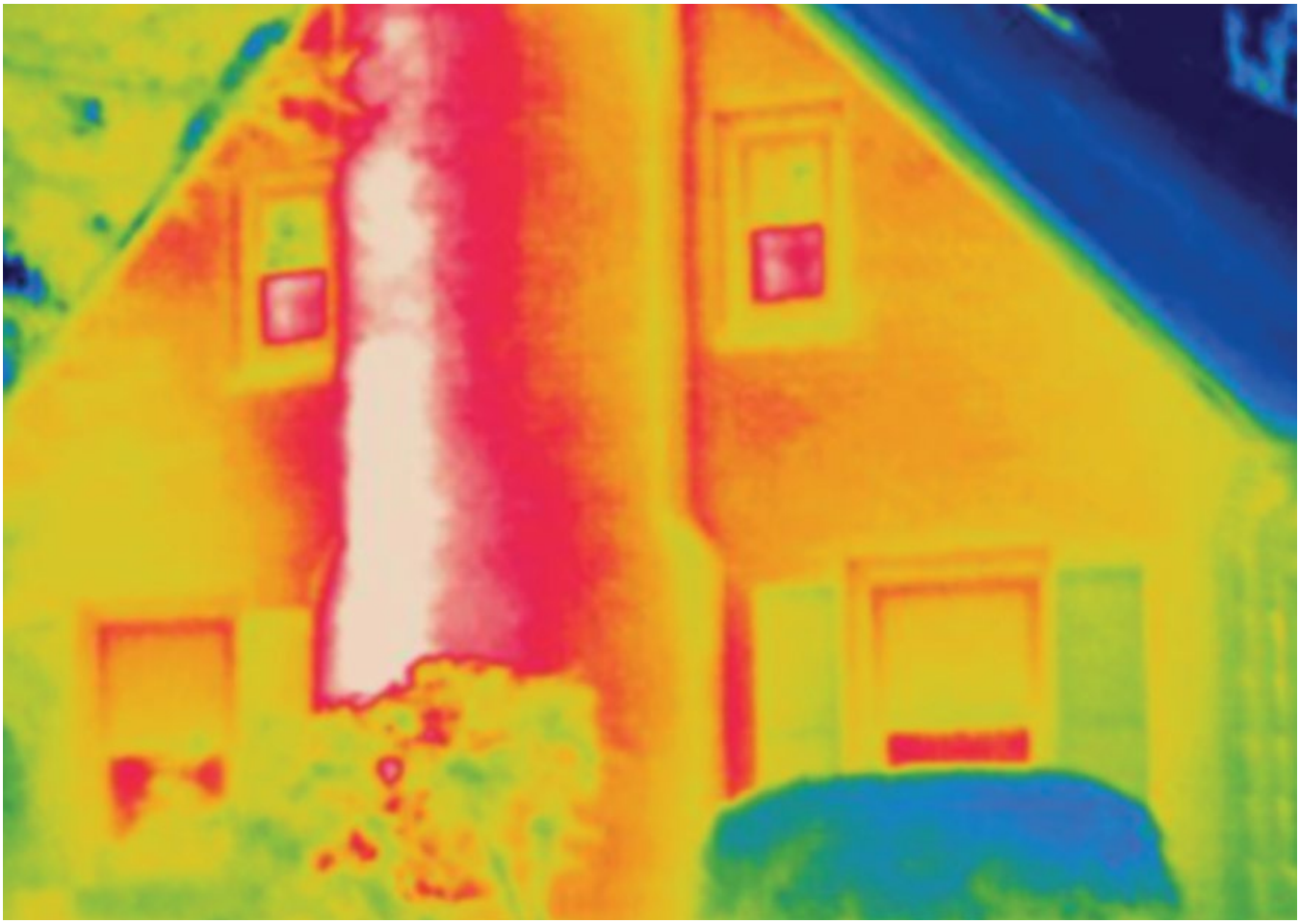
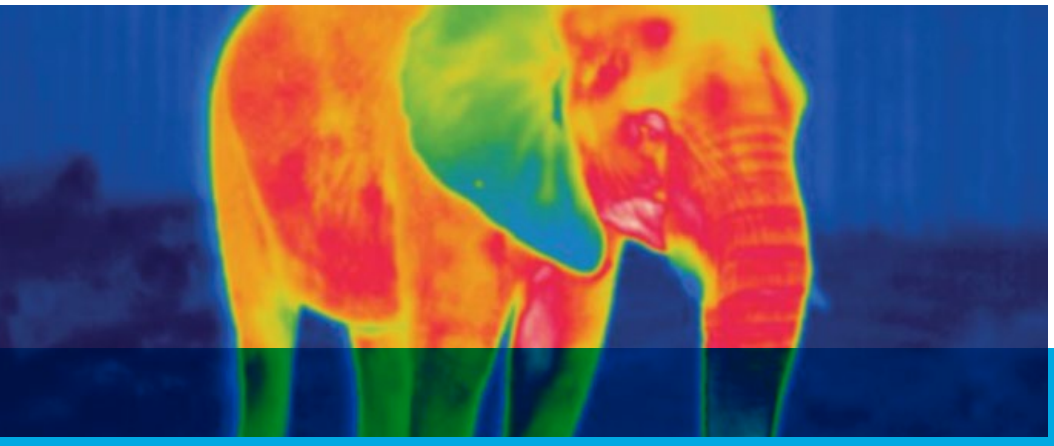
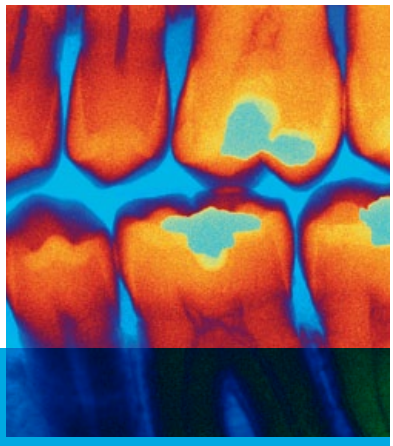
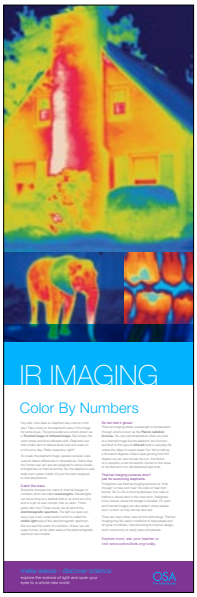


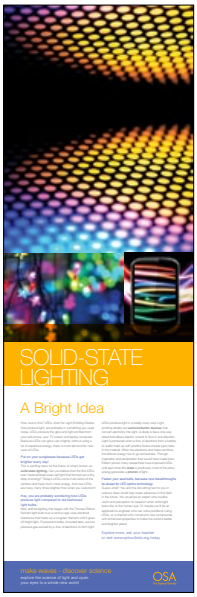




IR IMAGING

OSA





This poster series was created by The Optical Society and The OSA Foundation.

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Groot Gregory, Synopsys, Inc.; George Fischer, US Army; Le Qui, Harvard University; Jay Mathews, Arizona State University; San-Hui Chi, Georgia Institute of Technology; Christy Fernandez Cull, Massachusetts Institute of Tech Lincoln Lab; Prasanna Pavani, Ricoh Innovations, Inc.; Maruthi Manoj Brundavanam, University of Electro-Communications, Tokyo; Shalin Mehta, Marine Biological Laboratory; Yoshi Okawachi, Cornell University.

COLOR BY NUMBERS

Hey kids, how does an elephant stay cool on a hot day? Take a look at the elephant's ears in this image for some clues. The picture above is what's known as a **Thermal Image or Infrared Image**. Red shows the warm areas and blue indicates cold. Elephants use their cooler ears to release body heat and cope on a hot sunny day. Pretty awesome, right?

To create the elephant image, special cameras were used to detect differences in temperature. Colors that the human eye can see are assigned to various levels of brightness or thermal activity. So, the elephant's ears really aren't green inside, it's just the color assigned to that temperature.

CATCH THE WAVE.

Scientists translate the colors in thermal images to numbers which are called **wavelengths**. Wavelengths can be as long as a football field or as short as a tiny end of a pin or even shorter than an atom. That's pretty darn tiny! These waves are all part of the **electromagnetic spectrum**. The light our eyes can see is just a very small portion which is called the **visible light** area of the electromagnetic spectrum. We can see the colors of a rainbow. Unless you are super human, all the other areas of the electromagnetic spectrum are invisible.

SO HOT THAT IT GLOWS!

Thermal imaging relates wavelength to temperature through what's known as the **Planck radiation formula**. You can see temperature when you look at a thermal image like the elephant, but humans are blind to this type of **infrared** heat in everyday life unless the object is super-duper hot. We're talking a thousand degrees Celsius-type glowing hot! Hot objects we can see include the sun, the flames of a campfire, a red-hot electric burner on the stove or the filament in an old-fashioned light bulb.

THERMAL IMAGING CAMERAS AREN'T JUST FOR EXAMINING ELEPHANTS.

Firefighters use thermal imaging cameras to "look through" smoke and "see" the color of heat from flames. So if a fire is burning between two walls or behind a closed door in the next room, firefighters know exactly where the danger is located. Oh yeah, and thermal images can also detect where people are in a room so they can be rescued.

There are many other uses for this technology. Thermal imaging may be used in medicine to help people and all types of animals, manufacturing to improve design, and in astronomy to study stars and planets.

Explore more, ask your teacher or visit www.optics4kids.org today.

Activities

ACTIVITY 1: DETECTING IR LIGHT USING A CCD

WHAT TO DO

Remote controls for devices like televisions, cable boxes and DVD players typically operate in the infrared. On the front of the remote is a light emitting diode (LED) that produces light in the infrared region. The light flashes quickly to produce a sequenced pattern, which the device being controlled then reads and interprets as a command.

Digital cameras are typically made from silicon CCD's, which can detect light from the visible out to the near end of the infrared. The IR light does not focus as well, so it is usually blocked by a special filter so that it never reaches the CCD chip. This helps improve the camera's picture quality. Generally, the cheaper the camera is, the more IR light the camera can pick up. Thus, cheap digital cameras can be used to image the infrared. Webcams and camera phones are usually lower quality, so they work best for viewing IR.

Definitions

THERMAL IMAGING

Thermal imaging is the technology of sensing and recording the heat given off by an object to produce image of the temperature distribution. Thermal imaging cameras can detect invisible light due to the heat and produce images of heat distribution of the object.

FILAMENT

Filament is a fine or thinly spun thread, fiber, or wire. The electrical filament in an incandescent light bulb can be used to emit light due to its high temperature.

INFRARED CAMERA

Infrared camera is a camera that can detect infrared light and produce images.

BLACK AND WHITE PHOTO

Black and White photo is often abbreviated B/W or B&W photo. It is a term referring to a number of monochrome forms in visual arts.

FEVER

Fever is an abnormal condition of the body, characterized by an undue rise in temperature, quickening of the pulse, and disturbance of various body functions.

INFRARED (IR)

Infrared (IR) light is electromagnetic radiation with a wavelength longer than that of visible light, measured from the nominal edge of visible red light at 0.74 μm (read as micrometer, 1μm=10-6 m), and extending conventionally to 300 μm. These wavelengths correspond to a frequency range of approximately 1 to 400 THz. (1THz=1012Hz)

FAST FACT

Everything in the world that is above absolute zero emits thermal energy. That means everything is measurable!

Point a cheap CCD camera (camera phone or webcam) at the LED on the front of the remote control and view the image on the phone/computer. Now start pressing buttons on the remote. Without the camera, you will not see the LED light up, as the radiation is outside the visible range. Through the camera, you should see the LED get very bright when you press buttons. The light is being produced by the LED, but your eyes cannot see into the IR like the camera.

WHAT YOU NEED

- TV/cable/DVD remote control
- Webcam or camera phone

ACTIVITY 2: DETECTING IR LIGHT USING A THERMOMETER

WHAT TO DO

Light coming from the sun is made up of a large range of wavelengths. It contains light from the ultraviolet, visible, and infrared regions. Much of the UV is filtered out by our atmosphere, leaving mostly visible and infrared radiation. We can see the visible with our eyes, but what about the infrared? When light is absorbed by a material, it can heat up. We can use this property of light to detect light that we cannot see.

Cover the tip (metal part) of the thermometer with a piece of black tape. This will help it absorb light. Put the prism in the path of the sunlight and use it to create a rainbow pattern on a flat, white surface (The distance between the prism and the flat surface will determine the width of the rainbow spectrum. Larger distance will allow it to spread out more, but intensity will be lower.) Place the tip of the thermometer in the blue region and leave it for two minutes, then record the temperature. Do this again for the green and the red. Now put the thermometer in the region just past the red, where there appears to be no light, and record the temperature again. Where is the temperature highest?

WHAT YOU NEED

- Prism
- Thermometer
- Black tape

Lars Rindorf

IMAGINE BEING AS SMALL AS AN ANT. What would your back yard look like? Blades of grass would sway high in the sky. Itty-bitty stones would resemble huge boulders. What if you were even smaller? Say, *fifteen hundred million times smaller*. Suddenly, you'd see everything at the "nanoscale." (The prefix "nano" means "billionth," so a nanometer is one billionth of a meter.) Atoms, molecules, proteins and cells that make up all the things we know would completely surround the "Nano you." Whoa!

Welcome to the world of Lars Rindorf. Lars works with nanotechnology as a Senior Consultant at the Danish Technological Institute in Copenhagen, Denmark. Lars creates innovations that are incredibly small. He prints structures on surfaces which are so tiny they can't even be seen under a microscope!

"Specifically, I'm a computer simulation specialist," explained Lars. "I use a powerful computer to calculate how light behaves at nanometer scale."

Lars's work is hugely important. Right now his area of concentration is optical antennas. These are like antennas for TVs but much, much smaller than a speck of dust. "You could put thousands of them on the end of a hair," exclaimed Lars.

Even though these antennas are amazingly tiny, they have enormous potential to help make the world a better place. They can be used for new sensors that detect diseases. In the future, these sensors will reveal whether you are ill way before you even know it yourself. So people can be cured of diseases long before things get serious. Oh, and optical antennas can be used to create new types of solar cells for generating electricity that cost far less than today's expensive coal or oil fossil fuels.

You are probably wondering how Lars managed to get one of the coolest jobs on the planet, right? Well, Lars explained that he didn't start out studying optics. Growing up in Copenhagen, he was just plain curious about the world around him. Soon Lars discovered he loved math, and in college at the Technical University of Denmark, he trained in physics and mathematics. Lars finally decided on optics for his doctorate (Ph.D. for short).

"I'm a third generation scientist," said Lars. "My grandmother was a scientist in my university for many years. But I have chosen to be a scientist on my own."

Lars emphasized that you don't make a good scientist just because your dad or mom or grandma was a scientist. You need to follow your own interests. "You can't fake it," he said.

Having a mentor (a wise and trusted person to help with studies and ideas) helped shape Lars's scientific pursuits. Lars had two mentors: "My master thesis advisor and Ph.D. advisor are both really intelligent persons, but also quite demanding. I have had to deliver my work on time and it had to be really good."

Lars described that his studies were the equivalent of taking an exam two times a week for several years. "You have to try hard if you are to do something well. This is true in science as well as sports," said Lars.

Lars enjoys spending time with his children and listening to modern music. At the same time, the power of science never ceases to captivate his imagination. "It amazes me when I look at the stars and think about what is happening out there so far, far away in terms of science and the laws of physics. When I sit here I know that the same physical laws apply to create this computer screen and my computer. Without physics there would be no electronics. Science is really powerful!"

Lars Rindorf, Senior Consultant, Danish Technological Institute, Denmark.

Lars believes that now is the best time ever to work in the field of optics. "The most fascinating thing about optics is the many career possibilities that it offers," he explained. Lars sees optics at work in the advanced technology that surrounds us in everyday life. "Take a look at your smartphone—the rich colors and touch technology. The light emitting diodes (LEDs) use almost no energy and cost very little but allow us to do astonishing things that weren't possible even a decade ago."

What Lars also finds so interesting about his work is that he meets with some of the best scientists in the world. And you know what? He found them to be ordinary people like everyone else.

"You have to be a well-rounded person to be a good scientist," explained Lars. "Follow your interests. Take charge of your education. Remember that what you learn today may not be relevant in the industry next year. Things change with time. Learn subjects that are essential, and then you can put that knowledge to use later."

You have to be a well-rounded person to be a good scientist. Follow your interests. Take charge of your education.

Dale Herman Martz

DALE HERMAN MARTZ DOESN'T GO TO WORK. Rather, Dale wakes up every morning to "play with technology" as he terms it, at the Massachusetts Institute of Technology (MIT, for short) Lincoln Laboratory in Lexington, Massachusetts.

Dale is an engineer in the advanced laser technology and applications group. He specializes in developing beam combination schemes with ultra-fast high-power fiber laser systems. Sounds like science fiction, doesn't it? Then he finds specific applications or uses for this crazy new technology. "Building systems that utilize many different areas of cutting-edge technology is a very fun thing to get up and do every day," Dale explained.

At a young age, Dale was awestruck by science. Watching the space shuttle take off into the cosmos was a defining experience that had a lasting impact. Dale also watched his mother work on satellites. It was his first introduction to science and from there his curiosity sky-rocketed. Dale suddenly noticed that the world around him was filled with wonderful technology. By the time he was in fifth grade he was thrilled to have his very own Macintosh computer with a point-and-click mouse and video editing capabilities. "Playing with these devices and seeing the internet come to fruition were certainly drivers for my interest in technology," he reminisced.

Dale confesses that he is addicted to learning. He graduated in 2004 from Colorado State University with a bachelor of science summa cum laude (which means "with highest distinction") in electrical engineering. In 2006 he earned a master of science and in 2010 a doctor of philosophy. Thereafter, he traveled far away from his home in Colorado where he did his post-doctorate at KTH Royal Institute of Technology in Stockholm, Sweden.

The world of science continues to fascinate Dale in so many ways. But do you know what? He specifically chose to work in the field of optics! "I was guided to optics by the work being done at Colorado State University because it pushes every area of science to the limits," he explained.

Dale really does explore science to the outer limits. He has a long list of research interests from lasers and power electronics to control systems, nano-technology, X-ray microscopy, material science, communications and optics fabrication. But do you know what? Even though Dale has some super-serious scientific pursuits, it doesn't stop him from having fun outdoors with his family in the Rocky Mountains in Colorado. He is an Eagle Scout, so backpacking and backcountry camping, hiking, kayaking and skiing are all on his favorite-things-to-do list. Oh, and check this out: He likes to brew beer and listen to live music, too. Maybe someday he'll have his own "Optical Laser Light" brand beer!

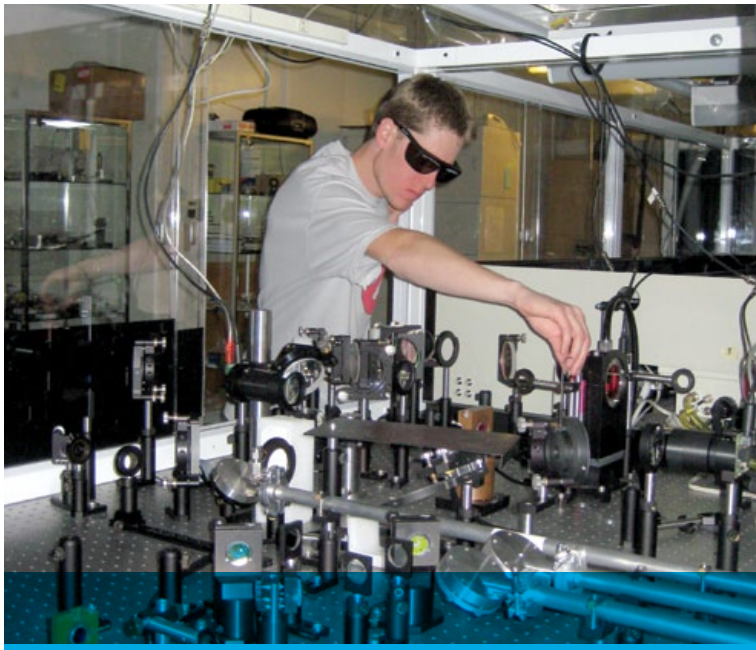
Of course, having an abundance of energy and a great outlook on life doesn't mean Dale hasn't faced challenges along the way. Dale took specific measures to get where he is today by working hard and paying close attention to people as he grew up.

From his observations Dale has learned that talented people who excel at what they do are not worried about what other people think about them. "These people are truly independent and know what they want. They set goals for themselves and strive to meet those goals despite obstacles that get in the way," he said. This personal discovery has helped to shape Dale's view of the world as a place with endless possibilities, where each

individual determines his or her basic path. “Sure, good timing and some good luck may be how someone will make an impact on society so that they are known by generations to come,” he explained, “but I believe you will never make such an impact if you are not ready to take advantage of opportunities when they present themselves.”

Dr. Dale Herman Martz is super-proud to be a part of the cutting edge of optics development in the United States. And he continues to build upon his scientific knowledge! Recently, he was part of the Center for Extreme Ultraviolet Science and Technology—a research center composed of four institutions whose members aim to bring the benefits of extreme ultraviolet light to the masses. In a way, it is like bringing extreme winter sports to the Olympics, but in the world of science! Totally rad!

Anyway, while Dale was there, he was exposed to famous people who are ultra rock-stars in science. These individuals helped to give him confidence in his technological pursuits: Donna Strickland, co-inventor of the grating compressor; founding member David Attwood; Jorge Rocca from Colorado State University as well as Henry Kapteyn and Margaret Murnane from JILA (Joint Institute for Laboratory Astrophysics). These are some of the stars pushing science to the limits as pioneers in the field of Soft X-rays and Extreme Ultraviolet Radiation.



Dale Herman Martz “playing with technology” at Massachusetts Institute of Technology (MIT), USA.

Dale believes in the future of optics and encourages students to pursue their dreams. “There are many things happening from bio-photonics to high power laser systems,” Dale said. He also explained that there is a shortage of qualified technical people, which means there are many jobs.

Just think, if you love science now and pursue your dreams, you may someday go to work to play all day with science. Because with science the possibilities are, indeed, endless!

I believe you will never make such an impact if you are not ready to take advantage of opportunities when they present themselves.

Additional OSA Resources

For Students, Teachers and Parents

OPTICS DISCOVERY KIT

The Optics Discovery Kit provides educators with classroom tools and optics lessons. The Kit features 11 experiments that demonstrate basic principles of optics. Components include: lenses, color filters, polarizers, optical fibers, a mirror, a hologram, a diffraction grating and an anamorph. Also included are teacher and student guides.

OPTICS SUITCASE

Looking for classroom science experiments? The *Optics Suitcase* is an innovative, interactive presentation package designed to introduce primary school students to many of the concepts of optics as well as other sciences. Each Suitcase includes a teaching guide and materials for demonstrations and experiments that teach about optics in a fun, hands-on atmosphere. Topics include: polarization, diffraction and selective reflection. For more information, visit us at www.osa.org/en-us/membership/youth_education/optics_suitcase/

EDUCATIONAL WEBSITE

OSA hosts an award-winning educational website for students, teachers and parents. All material is designed to spark students' interest in science. The site features optics experiments, tutorials, demonstrations, games, optical illusions, career profiles, reference materials and more. Visit www.optics4kids.org to continue your explorations of optics.

MEDIA LIBRARY

The OSA Media Library directly links educators and students to videos featuring leaders and innovations in optics and photonics. Video categories cover interviews, technical sessions led by esteemed speakers, and exhibits showcasing the historical progression of the industry. Visit www.osa.org/en-us/membership/youth_education/media_library/ to explore our education video content.

FOR MORE INFORMATION ABOUT ORDERING ANY OF THESE PRODUCTS,
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The Optics Discovery Kit was created by volunteer members of the Optical Society of America. The kit is part of the Society's youth education outreach programming. To request more information about OSA and other educational materials, please contact the OSA Education programming staff at: opticseducation@osa.org.

OSA Educational Resources … *Exploring the Science of Light*

— Image courtesy of Ryan Gallagher: www.kineticphotography

OSA Optical Society of America OSA Foundation

THE OPTICAL SOCIETY (OSA)

Founded in 1916, OSA brings together optics and photonics scientists, engineers, educators and business leaders. OSA is dedicated to providing its members and the scientific community with educational resources that support technical and professional development. OSA's publications, events and services help to advance the science of light by addressing the ongoing need for shared knowledge and innovation. The Society's commitment to excellence and continuing education is the driving force behind all its initiatives.

THE OSA FOUNDATION

Inspiring the next generation of scientists and engineers

The future's great scientists are among the children of today and tomorrow. These children live and study around the world. Some have the resources and support needed to succeed, but many others do not. The OSA Foundation believes all students should have access to quality education resources and everyone should have the opportunity to explore scientific studies and career paths.

The Foundation focuses on advancing youth science education by providing students with access to science educators and learning materials through interactive classroom and extracurricular activities. To learn more about the Foundation and its funded programs or to request support for your program, please visit www.OSA-Foundation.org, e-mail foundation@osa. org or call +1.202.416.1421.

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