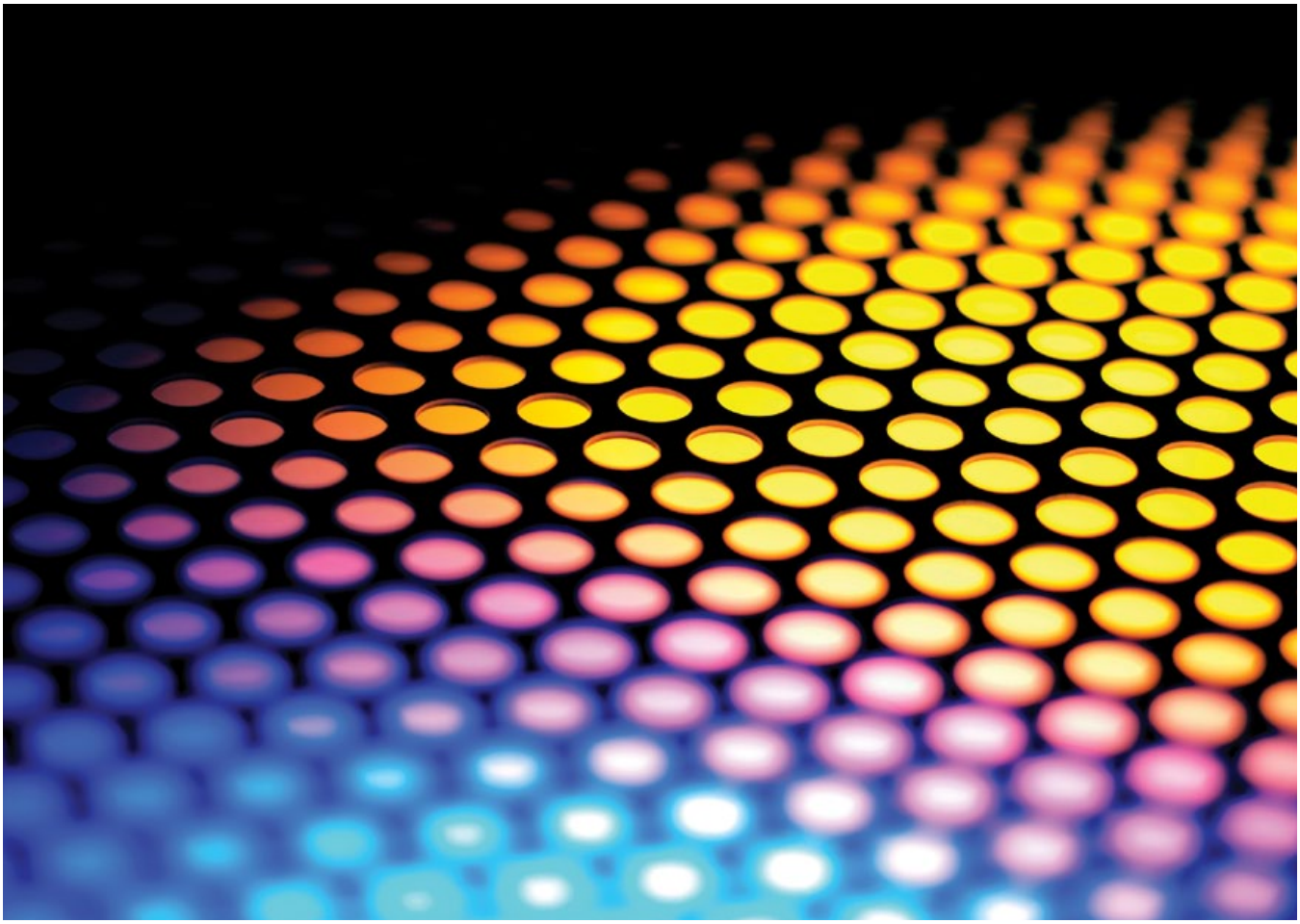
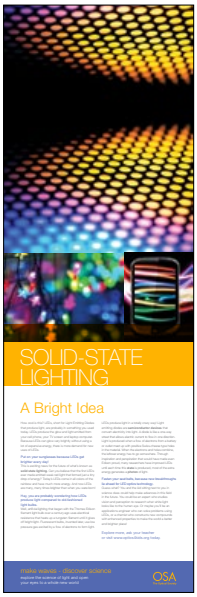
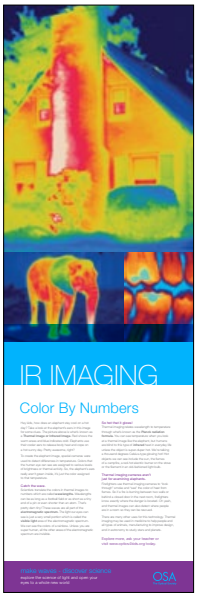


SOLID-STATE LIGHTING

OSA





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

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A BRIGHT IDEA

How cool is this? LEDs, short for Light Emitting Diodes that produce light, are probably in something you used today. LEDs produce the glow and light emitted from your cell phone, your TV screen and laptop computer. Because LEDs can glow very brightly without using a lot of expensive energy, there is more demand for new uses of LEDs.

PUT ON YOUR SUNGLASSES BECAUSE LEDs GET BRIGHTER EVERY DAY!

This is exciting news for the future of what's known as solid state lighting. Can you believe that the first LEDs ever made emitted weak red light that formed just a tiny drop of energy? Today's LEDs come in all colors of the rainbow and have much more energy. And now LEDs are many, many times brighter than when you were born!

HEY, YOU ARE PROBABLY WONDERING HOW LEDs PRODUCE LIGHT COMPARED TO OLD FASHIONED LIGHT BULBS.

Well, artificial lighting that began with the Thomas Edison filament light bulb over a century ago uses electrical resistance that heats up a tungsten filament until it gives off bright light. Fluorescent bulbs, invented later, use low pressure gas excited by a flow of electrons to form light.

LEDs produce light in a totally crazy way! Light Emitting Diodes are semiconductor devices that convert electricity into light. A diode is like a one-way street that allows electric current to flow in one direction. Light is produced when a flow of electrons from a battery or outlet meet up with positive Swiss-cheese type holes in the material. When the electrons and holes combine, the leftover energy has to go somewhere. Through inspiration and perspiration that would have made even Edison proud, many researchers have improved LEDs until each time this state is produced, most of the extra energy generates a photon of light.

FASTEN YOUR SEAT BELTS, BECAUSE NEW BREAKTHROUGHS LIE AHEAD FOR LED OPTICS TECHNOLOGY.

Guess what? You and the kid sitting next to you in science class could help make advances in this field in the future. You could be an expert who studies vision and perception to research what white light looks like to the human eye. Or maybe you'll be an applications engineer who can solve problems using LEDs, or a chemist who constructs new compounds with enhanced properties to make the world a better and brighter place!

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

Definitions

SOLID STATE LIGHTING (SSL)
SSL is a new technology for lighting homes, schools and streets using Light Emitting Diodes (LEDs). SSL consumes less electric power and lasts much longer than traditional incandescent and fluorescent lamps.

LED
LED is a semiconductor device that converts electricity into light efficiently. Light from LED bulbs looks almost identical to light from conventional bulbs.

ENERGY EFFICIENCY
Energy efficiency is the ratio of the amount of light emitted to the electric power consumed by a bulb. The amount of light is measured in units of lumens (lm) and electric power is measured in Watts (W). Incandescent lamp efficiency is 15 lm/W. Fluorescent lamp efficiency is 60 lm/W. With an efficiency of 100 lm/W, LEDs are much better than the rest.

LIFETIME
Lifetime is the number of hours a bulb lasts before it burns out. LEDs last for 30,000 to 50,000 hours, which is 50 times longer than incandescent lamps and 5 times longer than fluorescent lamps.

SPECTRUM
Spectrum is the decomposition of light into its constituent colors or wavelengths. Rainbows show us the spectrum of the sunlight. Sunlight consists of a large range of wavelengths, but our eyes can only see a small range of wavelengths that we see as different colors (violet to red).

FLUORESCENCE
Fluorescence is the conversion of a shorter wavelength of light (having higher energy) into longer wavelength (having lower energy) by a molecule. LEDs always produce a narrow spectrum of wavelengths. Phosphors coated on the LED can absorb this light and fluoresce to produce longer wavelengths. White light LEDs utilize fluorescence to convert the specific wavelengths that they produce into a spectrum that looks white.

SPECTROMETER
Spectrometer decomposes light into its constituent wavelengths. In this sense, water droplets floating in the air form a large-scale spectrometer that produces rainbow.

GRATING
Grating is any repetitive structure that can separate the light into its constituent wavelengths. Commonplace CDs and DVDs have fine grooves carved on them, which creates a reflective grating.

DIFFRACTION
Diffraction is the optical phenomenon by which a grating separates the light into its constituent components. Diffraction causes different wavelengths of light to transmit through or reflect from a grating at different angles, allowing a spectrometer to separate and measure intensity of individual wavelengths.

FAST FACT
The life of a regular bulb depends on usage. In home use of 3 hours per day, that is about 45.6 years of service for the LED. The regular bulb rated at 1,200 hours of service would last a little over a year (approx 400 days) at the same 3 hours per day.

Activity: Light Mixing

INTRODUCTION

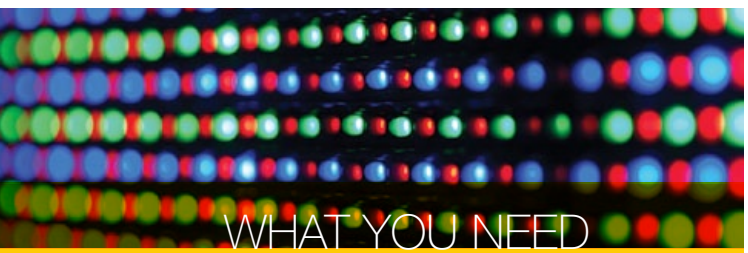
The goal of this series of experiments is to allow students to learn how different colors of light can interact and mix to produce various new colors. The experiment utilizes 3 different color LEDs (red, green and blue) to produce a wide range of colors.

OVERVIEW

Many of the current video displays, such as a computer monitor or TV, use the concept of additive color, where three different colors of light are combined in order to produce a wide range of colors. The primary colors often used are red, green and blue. Through different combinations and proportions, it is possible to cover the entire visible spectrum. For example, equal parts of red and green, green and blue and red and blue produce yellow, cyan and magenta, respectively. These generated colors are known as additive secondary colors. Combining all three primary colors creates white light.

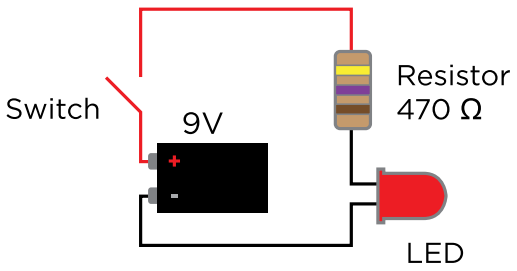
EXPERIMENT

In this experiment, three different LEDs (red, green, and blue) are used.



WHAT YOU NEED

- Red LED (brighter the better)
- Blue LED (brighter the better)
- Green LED (brighter the better)
- 9V battery (x3)
- Resistor 470 (x3)
- Switch (x3)



PROCEDURE

Shine LEDs on a white wall or white paper.

1. Try different combinations of LEDs to produce the three secondary colors.
2. Combine all three and see what color is created.
3. Change the amount of illumination of each of the LEDs by varying the distance to see if other colors can be created. For example, red and green in equal parts produce yellow. What is necessary in order to produce orange?

NOTES: A potentiometer can be added into the circuit in order to control the amount of current fed into the LED. This can be an alternative means of controlling the light intensity instead of changing the distance to the white wall/paper.

Oliver Dross

WOULDN'T IT BE GREAT TO COME UP WITH NEWFANGLED SCIENTIFIC IDEAS AND THEN MAKE THEM HAPPEN IN REAL LIFE? Well that's precisely what Oliver Dross does! He is a Function Owner for Philips Research in Netherlands—a global organization that introduces meaningful innovations that improve people's lives. Oliver's area of research is LED lighting. LEDs (short for light emitting diodes) are semiconductor devices that convert electricity into light. So when Oliver comes up with a new innovation in LED technology, it is always brilliant!

As an inventor, Oliver develops ways to use LED lamps to replace old-style light sources and lamps that use discharge or old-fashioned incandescent light bulbs. He invents and tunes the optical elements needed for lighting that families use every day. And guess what? His work helps everyone save money because using too much electricity can be really, really expensive.

Oliver Dross, Function Owner, Philips Research, Netherlands.

Some of Oliver's innovations are things we all take for granted. Smartphone lighting is one cool area on which he focuses. Others include color-changing lights for living rooms, lights for football arenas that provide sharper and livelier TV images and classroom lights with various settings that help students concentrate.

Oliver loves science. Especially the process of coming up with ideas, understanding theories and drawing conclusions about how things work. "If it can be proven in an experiment and it works just like predicted it really inspires me," he explains.

When Oliver was about your age and messing around with a computer, he started programming simple 3D graphics. Around the same time, he was captivated by the luminescence of the night sky and began to read about the cosmos and astronomy. Who could have imagined that the distant shining stars and planets of the Milky Way would be the catalyst for Oliver's interest in the science of light? Oliver found the mathematics a little intimidating at first but he explained how he got over that hurdle, "I lost fear of mathematics through a very good friend who taught me math I was curious about."

Now Oliver is having fun with math every day, calculating the shape of reflectors, lenses and light guides with complex design and analysis software.

Another part of his job is to think way into the future to try to figure out what type of lighting the planet will need ten years from now. What an amazing job! Hey, by then maybe Oliver will have fine-tuned a lighting navigation system for the nifty jetpacks that will propel us all around in the future!

In college at Universitat Konstanz Oliver had a chance to work in the optics lab. “It was a high level lab with a lot of huge lasers of different colors and large experimental setups. Of course, I was fascinated!” So once in a while Oliver still works in a dark lab adjusting optics.

Optics has taken Oliver on many exciting adventures. He spent six years in Madrid, Spain with influential professors Juan Carlos Miñano and Pablo Benitez who are quite famous in non-imaging optics, a field that departs from methods of traditional optical design. “It was a lot of fun to work with them... having the opportunity to discuss many novel ideas was an amazing experience.” He still has a passion for travel, but when he’s not traveling, he can always read about other places. Oliver just read a novel about the life of the settlers in northern Canada! Oh, and when he’s outdoors he likes to meet friends, make music, run, cycle and ski. Even when he doesn’t have to work, Oliver loves science so much he admits, “Sometimes I sit down to work on a new invention.”

Oliver believes in the power of optics and sees a bright future for the scientists of tomorrow. Just think, you could be one of those scientists! “Optics is a discipline that is applied in so many different fields and enables many upcoming technologies,” explained Oliver, “so I believe it will be a great area to work in.”

Oliver Dross lecturing in his classroom.

Think optics sounds awesome? Here is a message directly from Oliver to you that may help illuminate your path toward the field of optics and LEDs, “Study and read about different fields of science. Expose yourself to different cultures through travel, studying abroad and choosing to work on temporary assignments. The rest will come.”

Some of Oliver’s innovations are things we all take for granted. Smartphone lighting is one cool area on which he focuses. Others include color-changing lights for living rooms, lights for football arenas that provide sharper and livelier TV images….

Doctor Volker J. Sorger

HEY, WANT TO MEET SOMEONE WHO IS OUT-OF-THIS-WORLD? Introducing Doctor Volker J. Sorger: Professor. Entrepreneur. Humanist. Oh, and finalist in the European Space Agency's astronaut draft. Yes, Volker was about a nanometer away from becoming an astronaut! Now that is far out.

At a young age Volker was inspired by science. Back then he didn't really think of it as science. He simply had a fascination with nature—the sun, the planets, our galaxy. Volker reminisced, "I remember standing in our garden and dad was pointing a telescope at the moon and I would see craters in great detail."

Volker learned early on that one needn't be an intergalactic space explorer to make new discoveries. During his childhood Volker was drawn to man-engineered objects in motion such as ships, locomotives and airplanes in addition to space and nature. Before he knew it, in school right here on planet earth he discovered the wonders of math, physics, chemistry and geology.

Interestingly, the first topic Volker studied back in the eighth grade was optics when physics was introduced to the school curriculum. "From that moment I was fascinated by it," explained Volker. "The rainbow of a prism, the strong light of a laser and the many other exciting phenomena that optics is able to produce."

What is the allure behind optics? Well, Volker explained that as humans, we use our eyesight as one of the main senses to navigate through life and comprehend our surroundings. "The understanding of such life-guiding principles is surely fascinating for every human being, if introduced and nurtured properly," he said.

Today Volker Sorger has three very important roles. And, do you know what? He loves it that way. He explained, "What defines my work is that I am a professor, an entrepreneur and a humanist all at once."

In his first role as engineering professor, Volker performs research on new optical concepts at the nanoscale—a scale so small it can't even be seen under a microscope! Then, as an entrepreneur (a person who manages a business) he takes these new concepts and tries to put them to good use.

"For instance, I do research on what may become the first light computer," said Volker. In such a computer optical highways transport data rather than small electrical wires." Volker explained that the optical highways are faster and use significantly less energy than today's technology.

Volker Sorger's third role is that of humanist. "I have visions of a more humane and green planet, or simply a 'smarter' planet with improved living for all of us," he said.

Volker continues to perform research on solar cells that could solve the earth's energy crisis and looming climate change.

At the young age of 33 Volker has accomplished quite a lot. Along the way, his mentors—wise and trusted role models—have helped him tremendously.

Volker's mentors come in all shapes and sizes. The first was a physics teacher in high school who provided supervision and guidance when he did his first experiments in an after-school work group. The second was a close friend Volker made while at university who was twice his age and not even a scientist or engineer. He was in marketing! "He showed me who I am as a person, helped me define my professional goals and showed me how to convey them," explained Volker. And Volker still has a mentor today even though he is now a professor himself!

So much responsibility poses many challenges for Volker but he loves his work. “Being a leading figure in science such as a professor is like being a top manager for a large corporation. Your expertise is requested in many different fields ranking from teaching, advising your students, coaching post-docs, going to the laboratory and conducting experiments, meeting with various groups of interest and writing grant proposals. But let me say this, it’s super fun! After all, you are your own boss, so you decide how to manage your time on a day-to-day basis.”

What does Volker love most about science? “I appreciate the sincereness and truthfulness about science. Such advancement of the frontier of what this human race knows appeals to the very foundation what evolution is all about.”

Volker has a very clear vision with regard to the field of optics and he urges young people (Yes, that means you!) to go and study optics and photonics. “Many people believe that the 20th century was the century of the electron which led to integrated (IC) circuits and the computing power we have now,” Volker explained. “But this path has reached its physical limits in computing power. Moving forward can only be done with optics. Thus, the 21st century is the century of the photon: a light ‘package.’ Thus, is not only critical for computing, but for virtually every part of modern life.”

Dr. Volker Sorger, Assistant Professor & Director, The George Washington University, USA.

Oh, and in case you were wondering, Volker Sorger does has a life outside the lab. He enjoys dining with his lovely wife, talking about everything, biking and hiking together. “And exploring new places on this planet,” he added. Volker still has the desire to travel into space though. In life as in science most anything is possible, so perhaps Doctor Volker Sorger will still be an astronaut someday and YOU will be at Intergalactic Command Central!

Moving forward can only be done with optics. Thus, the 21st century is the century of the photon: a light package.

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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OPTICAL SOCIETY OF AMERICA

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(United States and Canada)

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www.edmundoptics.com

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.

OSA

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