



THE OPTICS SUITCASE

Educational Outreach
Presentation Guide

INTRODUCTION

The Optics Suitcase contains reusable supplies and give away theme packets for in-class presentations that explore color in white light. The goal is to help promote technology careers to children in school. A typical presentation takes up about 45 minutes, assuming the presenter has practiced with the materials.

Two Demos to Break the Ice

Heating Pad

Pick a student from the class and ask him (her) to come up and help you. Take the pad out, give it to the student and ask him (her) to gently handle the pad, holding it up for all to see. Get the child to agree that the pad contains a room temperature, squishy liquid. Holding the pad up where everyone can see, help the child to click the metal disc within. [This forces fluid through tiny perforations in the metal, thereby causing crystallization to commence within the liquid- you may have to try a few times.]

Crystallization and heat spread throughout the pad over several seconds. Prompt the child to now describe the pad—it has become hard and hot! This is an example of an exothermic reaction in a super-saturated solution. This commercial product is an instant heating pad for therapy and treatment of certain aches and pains. Training in chemistry and similar technologies gave someone the tools to invent this product. It is reusable by heating the pad for several minutes in boiling water to dissolve the crystals. Put the pad back into the Suitcase.



Happy/Unhappy Balls

Select another two students. Give each of them a rubber ball and ask them if the balls look and feel the same. [The answer is “yes”.] Ask each student to bounce the ball where others can see the zone of contact between ball and hard surface (desktop, wall or floor). One ball will bounce and the other will not. This is an example of polymer and materials science.

The “Happy Ball” is fully vulcanized; its composition was engineered to resist being deformed by contact with a hard surface. It would roll down an incline at a faster speed than the “unhappy ball”, since its coefficient of friction is lower. The “unhappy ball” deforms to absorb the shock of contact with a hard surface. It has no bounce. What is a good rubber for the bumper on a car? What rubber would be best for a handball, or the soles of a pair of sneakers? Put the demo away.

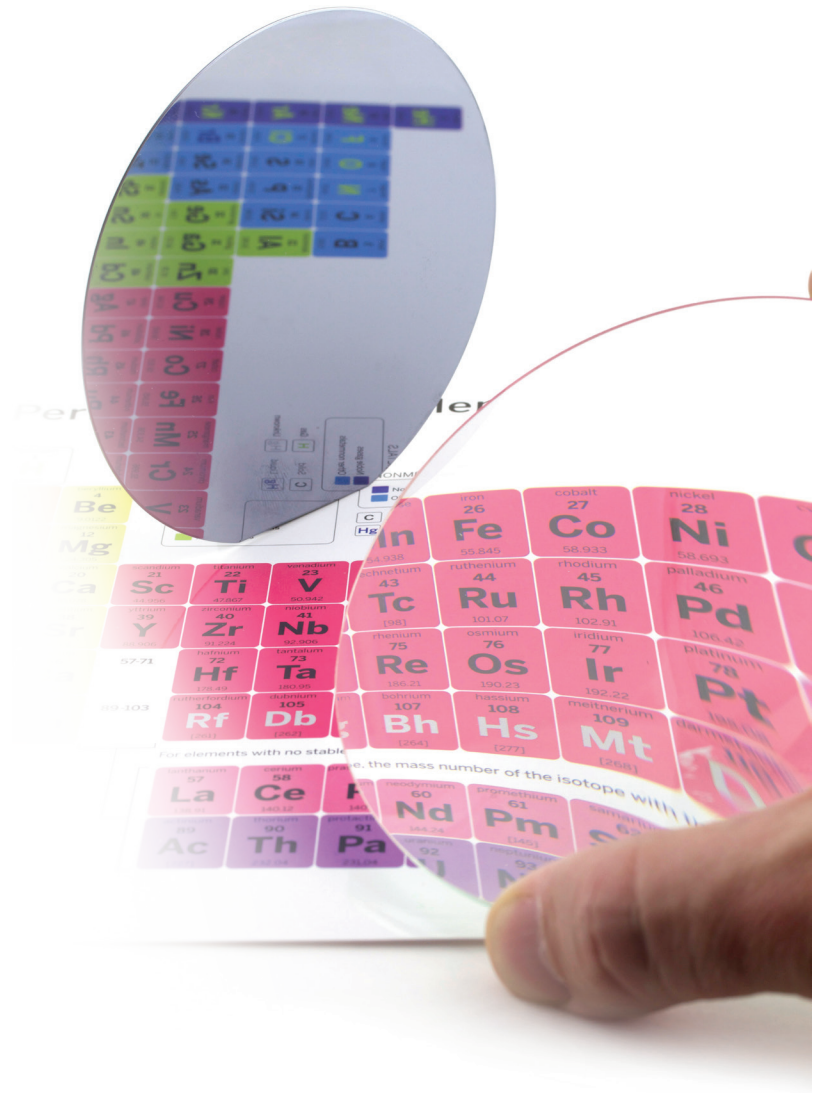
OPTICAL ENGINEERING

Silicon Wafer & Silica Lens

The sponsors of the Optics Suitcase want to promote careers in optics and optical engineering through the distribution of these teaching materials. To introduce this there are two optical elements in the Suitcase: a silicon wafer (thin, delicate, handle carefully) and a silica lens.

Hold up the silicon wafer, shiny side out, and the large silica lens for the class to see. Ask the students to identify these “optics”. [The lens is usually identified easily, whereas the wafer might be described as a “mirror”]. Identify the wafer as single crystal silicon, a pure elemental substance, and the basis for all computers (the chips and microcircuits). Show them the reverse side of the wafer which is dull, and explain that this side is ground and the other is polished to a mirror surface. Optical engineers develop the technologies for turning rough silicon wafers into integrated circuits for making computer chips. You may want to elaborate on this.

Hand out copies of the periodic table of the elements (useful for 8-9th grade and higher). State that the periodic table is a visual means for displaying all of the elements known to man—every bit of matter in the universe is composed of one or more of these elements. Ceramics engineers, chemists, materials scientists, geologists, and optical engineers work with many of these elements and the compounds they form. Explain that the only difference between the silicon wafer and the silica lens is oxygen. Help the students locate silicon (#14) and oxygen (#8). Point out that the addition of oxygen turns a visibly opaque material into a visibly clear one. Suggest that if we were aliens whose vision was in the infrared, the silica lens would look opaque and the silicon wafer would look transparent! Mention that optical engineers build lenses into systems that image light, such as the Hubble Space Telescope, the Chandra X-ray Telescope, digital cameras and cell or “smart” phones.



Take Home Theme Packet Experiments:

Tell the students that they are now ready for three experiments that reveal the colors in white light. Caution them that they must pay close attention, because there are certain “secrets” that you will reveal so they can take these experiments home to carry out with parents, brothers and sisters.

EXPERIMENT #1:

The Rainbow Peephole & Diffraction

Distribute the Rainbow Peephole theme packets, but ask the students not to open them yet. When everyone has their own packet, remove the flashlight and the peephole from your packet, hold them up, and identify them. Ask the students to remove theirs and figure out what to do by referring to the image of the young lady on the back of the packet. During the “oohs” and “ahs”, ask the group, “Where does the color come from?” [Many children will answer that the colors come from the peephole. Tell them that the colors come from the white light in the flashlight.] You can ask them to answer many questions. Do you see a regular pattern? Describe it. Identify all of the colors. Are they the same in each spot? Does the pattern change if the flashlight is close or far from the peephole? How? Does the pattern change if you rotate the peephole? Do you see colors from other people’s flashlights, even those far away from you? Do you see colors from the room lights?

Hold up the packet and show the picture on the front. Describe this as a highly magnified photograph of the surface of one side of the clear plastic in the peephole. It is taken with an instrument called an atomic force microscope. [Optical engineers and physicists invent instruments like this.] Note that the scale is in microns, that a human hair is 30 to 80 microns wide, and that the plastic has a regular array of small bumps across it that are only two microns high - too small to be seen or felt. The bumps are packed so closely together that about fifty of them could fit inside a human hair. State that these bumps are responsible for breaking up the white light coming into the peephole, depending on its color. This is called “diffraction”. Point out the similarity between the regular array of bumps and the pattern seen through the peephole. Conclude the experiment by stating that telecommunications and the internet use optical fibers and lasers and peepholes called “diffraction gratings”, taking advantage of dividing light from one spot into many spots, each with a different color. This is the key to unlimited numbers of conversations all over the world at the same time. People working in this field have jobs in “photonics”. Ask everyone to seal their flashlights and peepholes back into their packets. Remind them that the packets are theirs to keep. Suggest that they can reveal to family members the secret of seeing colors in white light through diffraction. They should never look through their peephole directly at the sun!



EXPERIMENT #2:

Magic Stripes & Polarization

Remove the slinky from the Suitcase and choose a volunteer to come up front. Give the student one end of the slinky and ask her (him) to hold this end steady at mid-chest level. Stand about 4 feet away and begin to vibrate your end up and down and in a circle. You should be able to create a standing wave with a few nodes, but the plane of vibration should not be well defined. State that, in addition to color, light has a wave nature to it. The slinky represents a light wave. This random motion represents unpolarized light - light without a preferred vibration direction. [For simplicity, we ignore circularly polarized light.] Stop the circular motion and vibrate only vertically. State that light is "polarized" when it vibrates in one direction—vertical or (switch hand motion) horizontal (this motion is a bit harder to maintain while speaking, and you might go back to the vertical motion.) Define linearly polarized light as light whose vibration direction is in a plane. Put the slinky away.

Hand out the Magic Stripes Theme Packets, but ask the students not to open them yet. When everyone has their own packet, ask the students to remove everything from the packet and place the 5 items on their workspace. Have them check that they have two dark pieces of plastic, one transparent piece of plastic with writing on it, a broken off fork, and a plastic vial. Take your two large pieces of linear sheet polarizer from the Suitcase and hold them up, one in each hand. Combine them about one foot in front of your face with the transmission axes parallel. You should be able to see the students, and they should be able to see you. Ask them to make a sandwich in the same way with their dark pieces of plastic. Tell them that these sheets of plastic are called "polarizers". Show them what happens when you rotate one polarizer relative to the other. They should do the same. During the "oohs" and "ahs", reveal that each polarizer has a secret code on its surface in the form of a small line. Combining the plastics with lines parallel allows for seeing through them. Combining with lines perpendicular, or "crossed", blocks the light. One plastic held up to the room lights causes the unpolarized white light to become linearly polarized. Once the light



is linearly polarized it vibrates in one plane (vertical, for example), and it is either transmitted or absorbed by the second plastic polarizer. Polarized sunglasses are made of this plastic.

If you have access to an overhead projector and can darken the room, you can place the large polarizers on the overhead projector and demonstrate how they polarize, transmit and extinguish the white light from the projector. Separate the crossed polarizers at four corners with the plastic cups to make a polariscope. Place the plastic silverware from the Suitcase in the polariscope, stand back, and enjoy the excitement. Ask where the color comes from. [You might get some correct answers.] Explain that stresses inside of transparent materials degrade the quality of linearly polarized light coming through the polariscope, causing various colors show up. With a polariscope, geologists identify certain crystals and mineral structures. Civil engineers examine stresses inside models of bridges made out of transparent plastic, to understand how to build them better. Photonics technicians evaluate the quality of laser glasses and laser crystals with polariscopes.

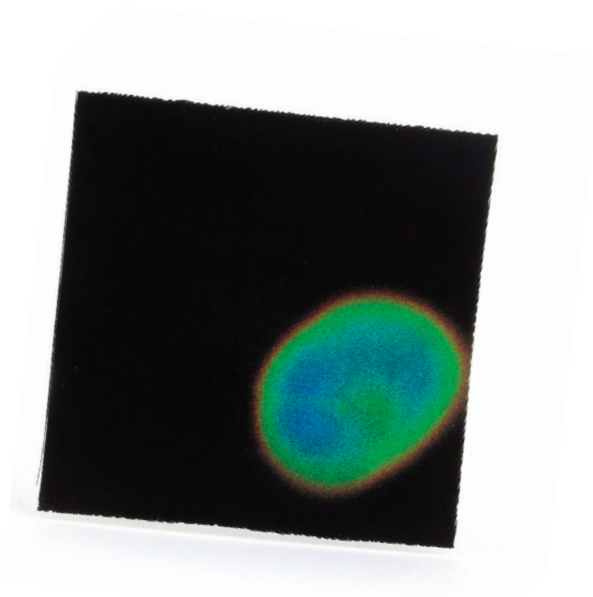
Have the room lights turned back on. With the items from your packet, show the students how to make a polariscope in one hand. Ask them to find the colored stripes in the clear sheet of plastic from their packet. [While looking through the crossed polarizer sandwich at the overhead lights, they must insert the clear plastic between the polarizers.] Ask the students to evaluate the internal stresses in the plastic vial and the fork. By squeezing on the tines of the fork, the students may be able to induce and visualize additional stresses. Have everyone put all items back in the packets. Suggest that, once home, the students may demonstrate the magic stripes trick to their families, since they know the secret polarizer code and how to construct a polariscope.

EXPERIMENT #3:

Magic Patch & Selective Reflection

Making sure that everyone is looking at you, take the large sheet of microencapsulated liquid crystal and place it against your face, shiny side out. [If you wear glasses, remove them first.] Wait a bit for the “oohs” and “ahs” to die out, then ask... “Where do the colors come from?” [If some students say the heat from your face, answer no.] Explain that the colors come from the white room lights reflecting off of the black “paper”.

Pass out the Magic Patch Theme Packets explain how the enclosed black plastic square has a liquid crystal fluid trapped, or encapsulated, in tiny bubbles on the shiny side. At just the right temperature (84-91°F or 29-33°C for this small square), these liquid crystal droplets reflect selective colors of white light. When the plastic square is cold there is no reflection and the square appears black. When the liquid crystals start to warm up, they start to reflect red light. Eventually, if they warm up sufficiently, they will reflect deep blue light.



This is selective reflection. “Mood rings” use selective reflection in liquid crystals to change color from the heat of your finger. Placing the shiny side facing out, ask the students to place the magic patch on their inner wrist to perform the vampire test. [Vampires are the living dead, and give off no heat.] Ask if anyone can “see” a vein”. [This would be characterized by a blue line.] The effect is reversible. Students may put their patches on an ice cube or under a mug of hot cocoa to see the effect of selective reflection. Give a warning that the sheet should not be folded up or marked with a sharp object like a pencil.

Acknowledgements

Developed by Prof. Steve D. Jacobs and the OSA Rochester Section in 1999, the Optics Suitcase is an innovative, interactive presentation package designed to introduce students, young and old, to the dynamic and exciting range of concepts within the study of light.

Funding and support for the Optics Suitcase comes from many generous sources including: OSA Rochester Section, the Laboratory for Laser Energetics (LLE) at the University of Rochester, the OSA Foundation, Masline Electronics, Edmund Optics and all of our passionate volunteers.

To request an Optics Suitcase, please visit us online at www.osa.org/optics_suitcase.

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This Optics Suitcase is dedicated to the memory of Dr. Stephen D. Jacobs

Dr. Stephen D. Jacobs made lasting contributions to the fields of optical materials, liquid crystals, and optics manufacturing, but it is his passion for educational outreach which continues to impact countless young (and older) lives. He spent his entire career at the University of Rochester with appointments at the Laboratory for Laser Energetics (LLE), Institute of Optics, Materials Science, and Chemical Engineering departments. He volunteered as the educational outreach chair for the OSA-Rochester Section for over 15 years during which time he developed and organized the Optics Suitcase program that has been instrumental in introducing hundreds of thousands of young children to the fields of optics and materials science throughout the US and globally.

Steve Jacobs touched many lives. His vision and desire to share optics continue with the every use of the Optics Suitcase.

REUSABLE SUPPLIES

- (1) Black suitcase with room for other items that you may add to customize your presentation
- (1) Instruction guide on laminated sheets
- (1) USB-stick with supplemental Optics Suitcase materials
 - additional fact and instruction sheets
 - template for flyer to hand out with take-home theme packets or to use for advertising the event
- (1) Hot Snapz – heat pad
- (1) Set of Arbor Scientific “Happy and Unhappy” balls
- (1) Slinky
- (1) 50-mm Silicon wafer, one side polished to a “mirror” finish
- (1) Silica glass lens
- (2) 5”x 5” pieces of high-quality sheet polarizer
- (4) Transparent plastic cups
- (1) Set of transparent plastic tableware: fork, spoon, knife
- (1) 6”x 6” sheet of temperature-sensitive microencapsulated liquid crystal (consider purchasing a “cold compress” instant ice pack for use with the LC demonstration)

GIVEAWAY SUPPLIES (can be re-supplied)

Take-Home Theme Packets:

- (50) Rainbow Peephole: TM Color by Redirecting (Diffraction)
 - (50) Magic Stripes: Color by Polarized Transmission (Polariscope)
 - (50) Magic Patch: Color by Selective Reflection (Liquid Crystals)
 - (50) Periodic Table of Elements
- Color flyers (not included, but template is provided)

Prepared by the OSA Rochester Section

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