**1 TINY LENSES FOR MINIATURE DEVICES:**

THIN, FLAT METALENSES COULD REPLACE BULKY GLASS FOR MANIPULATING LIGHT

By Alberto Moscatelli

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As phones, computers and other electronics have grown ever smaller, their optical components have stubbornly refused to **shrink**. Notably, it is hard to make tiny lenses with traditional glass-cutting and glass-curving techniques, and the elements in a glass lens often need to **be stacked** to focus light properly. Engineers have recently figured out much of the physics behind much smaller, lighter alternatives known as metalenses. These lenses could allow for greater miniaturization of microscopes and other laboratory **tools**, as well as of consumer products, such as cameras, virtual-reality **headsets** and optical sensors for the Internet. And they could enhance the functionality of optical **fibers**.

A metalens consists of a flat surface, thinner than a micron, that is covered with an array of nanoscale objects, such as jutting pillars or drilled holes. As incident light hits these elements, many of its **properties** change—including its **polarization**, intensity, phase and direction of propagation. Researchers can precisely position the nanoscale objects to ensure that the light that exits the metalens has selected characteristics. What is more, metalenses are so thin that several can sit atop one another without a significant increase in size. Researchers have demonstrated optical devices such as spectrometers and polarimeters made from stacks of these flat surfaces.

In a major breakthrough last year, researchers solved a problem called chromatic aberration. As white light passes through a typical lens, **rays** of its varied wavelengths get **deflected** at different **angles** and thus focus at different distances from the **lens**; to fix this effect, engineers today need to layer lenses in a finicky alignment. Now a single metalens can focus all the wavelengths of white light onto the same spot. Beyond creating this “achromatic” metalens, scientists have developed metalenses that correct other aberrations, such as coma and astigmatism, which cause image **distortions** and blurring.

In addition to reducing size, metalenses should ultimately lower the cost of optical components because the diminutive lenses can be manufactured with the same equipment already used in the semiconductor industry. This feature raises the alluring prospect of fabricating, say, a tiny light sensor’s optical and electronic components side by side.

For now, however, **expenses** are still high because it is difficult to precisely place nanoscale elements on a centimeter-scale chip. Other limitations also need addressing. So far metalenses do not **transmit** light as efficiently as traditional lenses do—an important capability for such applications as full-color imaging. In addition, they are too small to capture a large quantity of light, which means that, at least for now, they are not suited to snapping high-quality photographs.

Nevertheless, in the next few years the tiny lenses will probably make their way into smaller, easier-to-manufacture sensors, diagnostic tools such as endoscopic imaging devices, and optical fibers. Those potential applications are appealing enough to have attracted research support from government agencies and such companies as Samsung and Google. At least one start-up, Metalenz, expects to bring metalenses to market within the next few years.

**Answer for yourself these questions.** When ready, retell the main ideas of the article to your partner who has read a different article – you can use answers to these questions as your guideline.

1 Why is it difficult to make tiny lenses?

2 What is a “metalens”? Define it.

3 What is a “chromatic aberration” problem? How was it fixed?

4 What are some of the problems or limitations of metalenses so far?

5 What does your partner think about the issues addressed in this article?

6 Ask your partner a question regarding their article.

**2 SAFER NUCLEAR REACTORS**

Written by Mark Fischetti

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Controlling carbon in the atmosphere will require a mix of energy technologies—potentially including nuclear reactors, which **emit** no carbon but are seen as risky because of a few major accidents. That risk could be greatly reduced.

Commercial reactors have used the same **fuel** for decades: small pellets of uranium dioxide stacked inside long cylindrical **rods** made of a zirconium alloy. Zirconium allows the neutrons **generated** from **fission** in the pellets to readily pass among the many rods **submerged** in water inside a reactor **core**, supporting a self-sustaining, heat-producing nuclear reaction. Trouble is, if the zirconium overheats, it can react with water and produce hydrogen, which can explode. That scenario fed two of the world’s worst reactor accidents: the 1979 potential explosion and partial melt-down at Three Mile Island in the U.S. and the 2011 explosions and radiation **release** at Fukushima Daiichi in Japan. (The 1986 Chernobyl accident was caused by faulty reactor design and operation.)

Manufacturers such as Westinghouse Electric Company and Framatome are hastening development of so-called accident-tolerant fuels that are less likely to over-heat—and if they do, they will produce very little or no hydrogen. In some of the variations, the zirconium cladding is **coated** to minimize reactions. In others, zirconium and even the uranium dioxide are replaced with different materials. The new configurations could be slipped into existing reactors with little modification, so they could be phased in during the 2020s. **Thorough** in-core testing, which has begun, would have to prove successful, and regulators would have to be satisfied. In a bonus, the new fuels could help plants run more efficiently, making nuclear power more cost­-competitive—a significant motivation for manufacturers and electric utilities because natural gas, solar and wind energy are less expensive.

Although nuclear power has stalled in the U.S. and is being phased out in Germany and elsewhere, Russia and China are building aggressively. These markets could be lucrative for the manufacturers of these new fuels.

**Answer for yourself these questions.** When ready, retell the main ideas of the article to your partner who has read a different article – you can use answers to these questions as your guideline.

1 Can nuclear energy be seen as “green” energy? Why?

2 What kind of fuel has been used by commercial reactors? What is the danger connected to it?

3 What were the reasons for the reactor accident at Fukushima Daiichi in Japan?

4 Define “accident-tolerant fuels.” What are their advantages?

5 What does your partner think about the issues addressed in this article?

6 Ask your partner a question regarding their article.