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IN THE LABS
By Burt Helm

From Octopus Eye to Tiny Camera

The gangly sea dweller provides the insight for a new breed of superthin, flexible plastic lenses that could soon have wide use

Thanks to inspiration from an octopus, fuzzy images from your cell-phone camera could soon be a thing of the past. Case Western Reserve University professor Eric Baer and a team he's working with at the Naval Research Laboratory have developed a low-cost, single plastic lens that could match the quality of expensive lenses used in cameras. And soon, the lens will also be flexible -- allowing people to zoom in and out by giving it a squeeze.

Emulating the operation of an octopus' eye, Baer and his team stack hundreds of thousands of superthin plastic sheets on top of each other to create something lighter and flatter than a normal curved glass lens. Because the lenses are made of easy-to-manipulate plastics, the scientists will be able to build camera lenses with sharp focus at a fraction of the current cost and size.

That could enable simple amateur cameras to produce high-quality images now only possible with complicated professional models. It would also mean sharp lenses could fit into tight places –- like cell phones or on the tips of probes used in surgery.

SLIMMING DOWN. The technology uses a principle taught in introductory physics classes -- that light bends when it moves into a material of a different density. Scientists refer to this as a difference in the material's "refractive index." By giving each layer a slightly different density, a perfectly flat lens can bend and focus light as if the lens were curved. The lens of an octopus' eye, which must focus with several times the strength of a human lens to see clearly in water, combines a natural curve with this type of variation, enabling it to take advantage of both methods of magnification.

In the past, these "graded refractive index," or GRIN, lenses have been difficult to build precisely and could never focus with much strength. But Baer's method, which stacks hundreds of thousands of 50-nanometer-thick sheets on top of each other like layers of an onion, allows him to command stronger degrees of magnification and control his designs with a new level of precision. About 10,000 of these stacked sheets would be equal to the thickness of a human hair.

That advantage could be particularly useful in cameras, which now use as many as eight different curved lenses to correct aberrations. A typical 35-millimeter camera will use two or three. In these bulky systems, "You [begin with] a fuzzy image," says James Shirk, a researcher at the Naval Research Laboratory. "You then take another lens that makes a fuzzy image in the opposite direction to correct it," and repeat that again and again because, he says, curved lenses are intrinsically flawed.

SQUEEZE PLAY. Since GRIN lenses don't rely purely on curved-lens focusing and are made of plastic, they can bend light to the designer's exact specifications, Shirk says. A GRIN lens can be attached to a curved lens to correct all aberrations at once. That means supersharp focus in slim-profile devices. And because the technology uses commonly available plastics instead of precisely ground glass, the lenses are cheaper to manufacture.

That said, these lenses still need to be proven in the marketplace. "We're really early in this technology, and we haven't produced anything near the [theoretical] limit" says Shirk. "The first of these lenses were made less than a year ago." While the lenses the team has built so far have focusing power equal to a pair of reading glasses -- Baer has made himself a pair -- Shirk believes they'll be able to triple the magnification capabilities as they refine their techniques.

The next step is making the lenses out of a soft, flexible plastic. That way someone could change the focus -- and zoom in and out -- simply by squeezing. "In principal, it's easy," says Shirk, "but making the lenses out of [elastic plastic] is tough." Once that hurdle is overcome, powerful optical zooms could be built into phones, cameras, and specific medical devices like surgical cameras, where today's long zoom lenses wouldn't normally fit. That could be accomplished in a year or two, says Baer.

DIFFERENT JOBS. The military, which is funding the research, will get the first crack at the GRIN lenses. A prototype of an unmanned flight vehicle has been equipped with a GRIN, and the team hopes to implement them in on-board guidance systems on missiles. Baer says he's also in talks with several companies to license the technology commercially, though he declines to go into specifics.

Would he consider starting his own company? "[Business] is not my area of strength. My job is in education." says Baer. "But I'd definitely like to see these types of lenses on the open market." That day seems to be coming.

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