Photorefractive Polymers for Holographic 3-D Display

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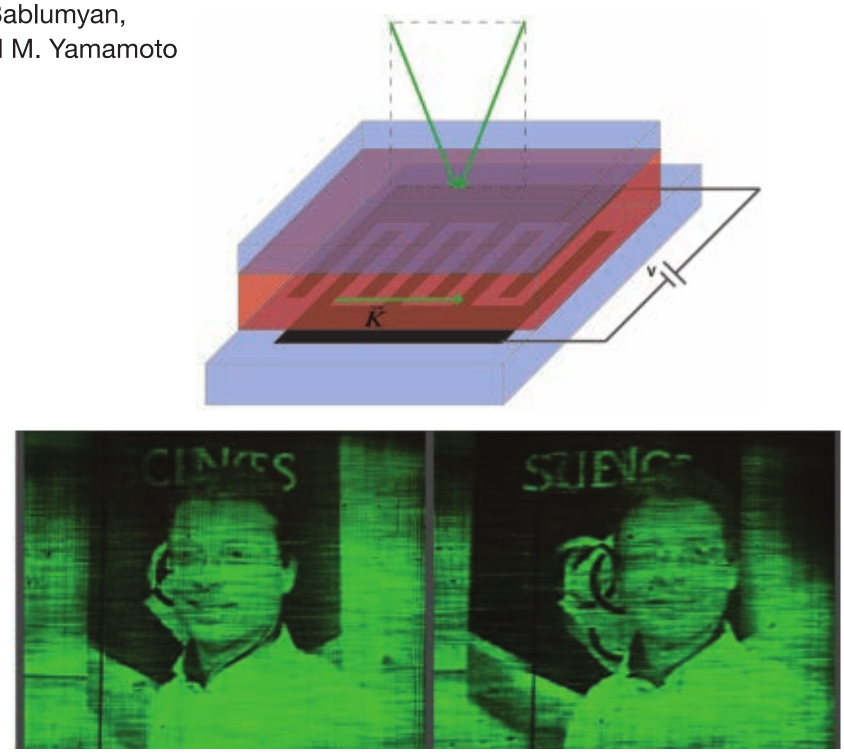
In a recent *Nature* article, we demonstrated 3-D holographic telepresence using photorefractive (PR) polymers,[1] which are among the few rewritable holographic recording materials. They are also self developing and can be cast onto large surfaces such as plastics. The index of refraction of PR polymers can be changed upon illumination. The mechanism is fully reversible since it involves the redistribution of charge particles. There is no need for post-processing to reveal the hologram. Recent improvements in the material and geometry of the device have boosted the performance of PR materials and their applications as holographic 3-D display media.[2]

Up until now, 3-D displays have struggled to reproduce all the information present in natural scenes. Most current displays rely on stereoscopy, requiring the viewer to wear special eyewear, and they present only a small number of perspectives. In such systems, the vergence accommodation conflict leads to physiological effects such as eye strain, headache and motion sickness. Holography, on the other hand, is known to reproduce the entire light field: amplitude and phase. This means all the optical cues can be recreated for a display.

Usually, the PR display devices are built as multilayer structures with the active material sandwiched between two transparent ITO-glass electrodes. The electric field, applied between those electrodes, runs along the thickness of the PR polymer, which is not the best configuration since the grating vector and poling fields are parallel to each other; this leads to the use of slanted geometry to obtain the highest diffraction efficiency, making the system design complicated and requiring higher laser powers for hologram writing. The theory of PR materials predicts a much more efficient device provided that the external electric field was applied parallel to the surface of the device. To do so, we patterned the electrodes as two interpenetrating combs.[3] Printed on the top of the PR film, now the field points from one tooth of the comb to next, and its horizontal component is dominant. We demonstrated an increase in sensitivity up to five times with coplanar electrodes as compared with the perpendicular electrode design, leading to bright images for our holographic 3-D display with reduced laser writing power.



(Top) Interdigitated coplanar electrodes geometry. (Bottom) Pictures of the holograms recorded with the 3-D holographic telepresence system.

So far, we have demonstrated that a PR-based holographic 3-D display can reproduce full color and full parallax.[1] It displays correct cues in both accommodation and vergence. The largest display we made had a 12 × 12 in. screen and resolution of 250 μm, comparable to HD TVs. By using the principle of integral imaging, a system based on 16 cameras was used to capture a live scene, transmit the information over the Internet and print the hologram in a matter of seconds. ◭

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