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OPTICS INNOVATIONS

Is It AR's Time to Shine?

A photonics company considers the lighting solutions that could pave the way for a consumer-driven augmented-reality revolution.

Ann Russell

The augmented-reality (AR) and virtual-reality (VR) market is growing rapidly, invading the gaming, social media and even manufacturing industries with awe-inspiring technology. In fact, according to research firm Technavio, the global AR/VR market is expected to grow by US$125 billion in the next four years.

However, while consumers are introduced to new VR headsets, consoles and games on an almost weekly basis, the same has not been true on the AR side. Over the past few years, some well-known companies have launched AR glasses for the consumer market, but the devices have yet to take off. The field is still waiting for mass-market adoption—although it seems that the demand for such technology continues to grow.

Both AR and VR require devices such as headsets, tablets or glasses to operate. AR technology is more challenging, however, because it must overlay the real world, while VR immerses users in one that's entirely digital. Often, a VR headset is used only for a short period, during which the device completely covers the eyebox—thus sidestepping the challenges of compact projector design. Meanwhile, comfortable and lightweight AR glasses are ideally worn all day. They must not interfere with peripheral vision and eye contact and, preferably, should cause minimal interference between the real world and the user.

Most of these requirements necessitate near-to-eye (NTE) display waveguides, breeding substantial challenges around the projector design and waveguides. Of course, workarounds to avoid guided waves also present their own issues. For example, back-illuminated LCD or OLED matrices need a front partial mirror, which requires reflection at an angle between the illuminating matrix and the users' eyes (sometimes referred to as "bird-bath"). This pushes the glasses out further from the face, limiting light from surrounding scenery and preventing eye contact, which many in the industry determine to be essential for mass AR adoption.

All of this begs the question: Could an improved light source help solve some of the complex issues thwarting AR's commercial success? At Osram, a world leader in AR lighting solutions based in Munich, Germany, we believe the answer is yes.

Straight to the source

The main obstacles to consumer AR glasses are size and weight, factors affected by the package of the components involved as well as the size of the required battery. It's possible to shrink the battery by efficiently coupling light from the light source into the optics of the AR glasses, but this requires a compact source that transmits light to a narrow solid angle (three-dimensional cone)—in other words, a source with high optical power density.

This power density can be quantified as watts per unit area per solid angle—and judging by this metric, lasers blow all other light sources out of the water. As the physical package size of light engines falls below 1 cubic centimeter, high-density and compact lasers are emerging as ideal light sources for AR and VR systems.

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Osram offers a broad range of pico lasers and LED components in various powers and packages, and as far as we're aware, it's the only optoelectronics company with a reference design to start mass adoption of laser beam scanning (LBS) for NTE displays. At Osram, we've found that LBS offers many system advantages for AR consumer glasses, including a compact size and low power, which is ideal for all-day wear.

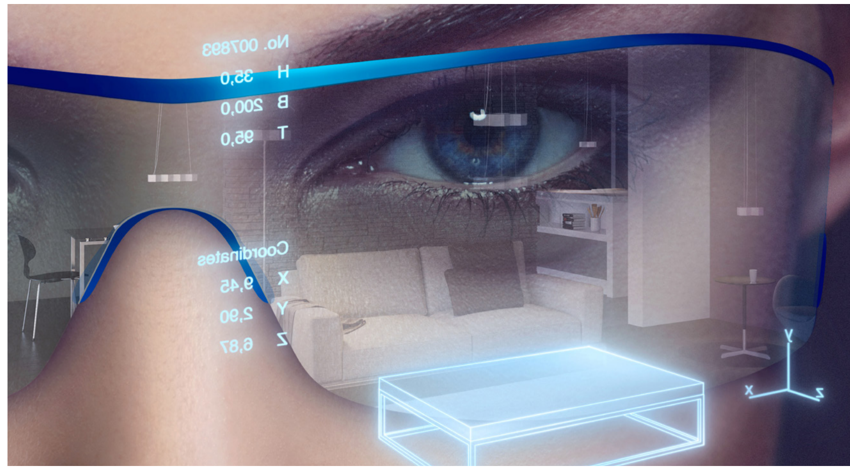
The LBS advantage

Getting light into the waveguide of an NTE system has never been easy. Mismatches in etendue—how "spread out" the light is—between light sources and lighting requirements of pico projectors and waveguides can present numerical-aperture mismatch issues. As mentioned above, narrow laser beams address efficiency issues, while the scanning process reduces speckles—nonuniformities generated by a coherent, single-color light source.

In LBS-based systems, the scanned beam underfills the waveguide entrance so that all light can be accurately uncoupled from a scanning mirror, through the relay optics, and finally onto the waveguide entrance. When done correctly, all light is used for illumination thanks to the laser's sharp beam. This approach makes lasers more efficient as AR device sources than other technologies.

The second key advantage of LBS is reduction in projector size when coupled with a 2D beam-expansion waveguide. The most compelling waveguide solutions on the market achieve 2D beam expansion using diffractive or refractive waveguides. Internal beam deflectors allow for 2D aperture expansion and enable small initial aperture optics, another key advancement in the AR space.

Using this technique, a scanning mirror with a millimeter-sized entrance will project an image over a short, effective focal length onto the entrance pupil of the waveguide. In such a setup, the relay lenses are also small, which significantly reduces the entire distance of the optical system. Next, the millimeter-sized aperture will expand into a larger aperture (the resulting eyebox) after internally reflecting through the waveguide



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into the users' eyes. With a 1.5-arc-minute resolution, the user of such a system is ultimately rewarded with a tiny projector encased in the glasses stem and enough optical fidelity to read text.

LBS also offers improved efficiency via selective illumination; only the required portion needed in the display uses precious battery power. This offers an immediate improvement over flood illumination seen in liquid crystal on silicon (LCoS) or digital light processing (DLP) NTE projectors. There is always a tradeoff, however—LBS currently affords a lower resolution than that seen in a 4k LCoS display, for example.

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More than meets the eye

The selective illumination, efficient light coupling into waveguide and compact system design make a compelling case for lasers in NTE illumination. And although there are still challenges, several previous drawbacks—such as speckle, unwanted polarization and system flicker—are now being addressed through innovative packaging and chip development, including polarization mixing and wavelength offsets.

While AR may not be living up to its full potential today, it is being used in a variety of applications. On assembly lines, AR shows workers exactly where a part should be placed; in construction and interior design, it paints a picture of how a building or room will look before it's completed; and on entertainment platforms, AR is a critical component for games like Pokemon Go or social-media filters that alter users' faces. With the addition of consumer glasses, Osram expects that AR will take its next leap forward and change how we see the world—literally. OPN

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