

Technology Offer

Display Engines and Systems Using Photonic Integrated Circuit Chips with Integrated Actuators

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Abstract

This invention presents an innovative display engine for laser-scanning head-mounted displays, utilizing photonic integrated circuit (PIC) chips with integrated actuators. The system generates multiple intensity-modulated laser beams that are scanned across a user's field of view via actuators embedded in the chip, an off-chip scanning mirror, or a hybrid of both. The output couplers on the PIC chip emit the beams, which are then expanded and directed toward the eye through an optical combiner and relay optics. This technology significantly improves scalability, resolution, and field of view while reducing system complexity, opening new horizons for compact and high-performance augmented reality and mixed reality devices.

Background

Traditional head-mounted displays (HMDs) rely on bulky peripheral light engines and complex optical combiners, facing challenges in size, brightness, and field of view (FOV). Laser-scanning HMDs offer brightness and contrast advantages but suffer from tradeoffs between resolution, scan speed, and FOV. Furthermore, their reliance on large, free-space optical setups complicates miniaturization and mass production. As demand for lightweight and high-resolution near-eye displays grows, particularly for AR and XR applications, a need has emerged for systems that combine high optical performance with a compact, manufacturable architecture. Photonic integrated circuits offer a promising route to address these critical limitations.

Technology

The disclosed technology utilizes photonic integrated circuit (PIC) chips fabricated from materials like silicon nitride (SiN) or silicon oxynitride (SiON), enabling efficient light guidance in an extremely compact form. Lasers emitting at red, green, and blue wavelengths are flip-chip bonded directly onto the PIC, where optical waveguides route the beams to output couplers positioned at the chip's facet. These couplers, which can be edge emitters or grating emitters, project intensity-modulated laser beams into free space. Integrated actuators, based on thermal or electrostatic mechanisms, dynamically reposition

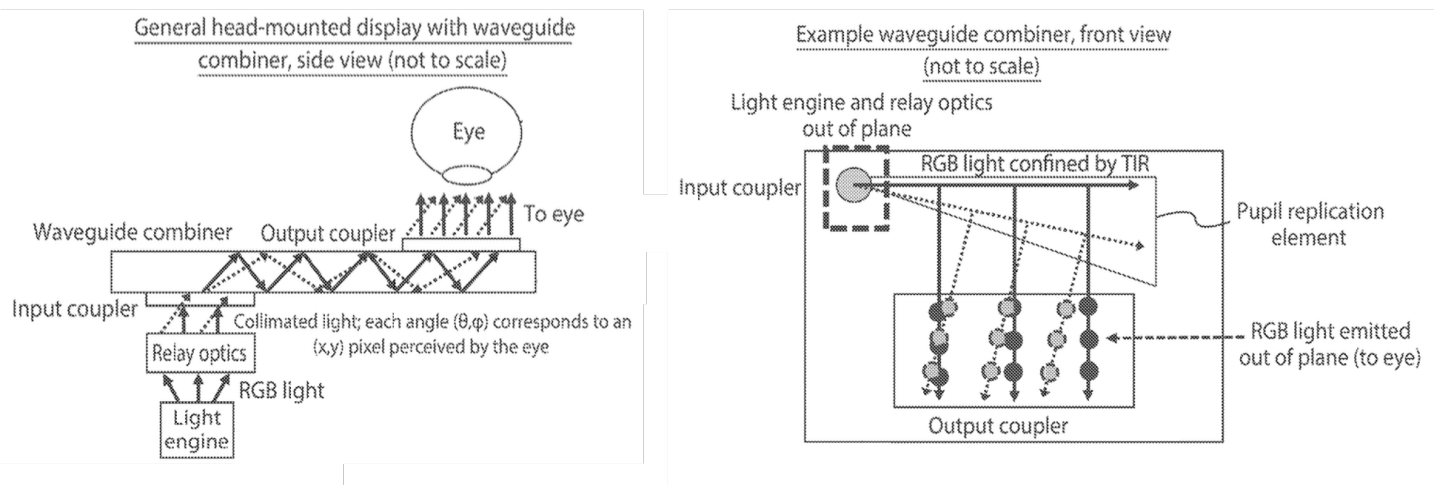


Figure 1: Schematic side and front views of a head-mounted display system using a waveguide combiner. The system guides RGB light from a light engine through relay optics into an input coupler. Inside the waveguide, light is confined by total internal reflection (TIR), replicated via pupil replication elements, and emitted toward the eye through output couplers, forming a high-resolution image.

the output couplers to scan the beams across the field of view (FOV). The system can combine on-chip actuators with off-chip scanning mirrors for two-dimensional beam steering. Relay optics, including lenses and diffractive elements, collimate and direct the beams into an optical combiner, which projects the final image toward the user's retina. Multiple independently modulated beams operate in parallel, each covering a segment of the FOV. This parallel addressing significantly relaxes demands on scanning speeds and laser modulation frequencies, enabling wide FOVs and high resolutions without complex or bulky free-space optics. The architecture supports stacking multiple PICs, forming two-dimensional emitter arrays, further enhancing scalability and display quality. Wafer-scale fabrication ensures high reproducibility and integration potential for mass production.

Advantages

- **Compactness:** Integration of lasers, waveguides, and actuators onto a single chip enables ultra-small and lightweight display engines.
- **High Resolution and Wide FOV:** Multiple parallel beams enhance image resolution and extend the field of view without requiring extreme scanning speeds.
- **Scalability:** Photonic chips can be stacked or combined to support larger displays or higher pixel densities.
- **Lower Power Requirements:** Reduced need for high-speed modulation and scanning lowers energy consumption and simplifies system electronics.
- **Manufacturing Efficiency:** Compatible with wafer-scale fabrication and flip-chip bonding for cost-effective, high-volume production.

Potential applications

- **Augmented Reality (AR) Headsets:** For lightweight, high-resolution overlays in consumer, enterprise, and industrial environments.
- **Mixed Reality (MR) and Extended Reality (XR) Glasses:** Providing immersive, lifelike visuals for training, gaming, and professional applications.
- **Wearable Display Systems for Industrial and Medical Use:** Enabling precision visualization in hands-free, portable formats for critical operations.
- **Military and Aviation Head-Up Displays (HUDs):** Delivering rugged, high-performance imaging systems for pilots and soldiers in demanding conditions.
- **Consumer Smart Glasses with Integrated Display Technologies:** Supporting everyday applications such as navigation, communication, and entertainment with minimal device footprint.

Patent Information

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