Technology Offer

Photonic Integrated Circuit for Dual-Axis Beam Steering in AR and LiDAR Applications

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Abstract

This invention discloses a photonic integrated circuit (PIC) designed to emit low-divergence, steerable light beams, suitable for integration into compact optical systems such as augmented reality (AR) glasses and LiDAR devices. The PIC integrates arrays of lasers, waveguides, and diffraction gratings on a movable platform that can tilt in two axes, allowing for precise two-dimensional beam steering. Multiple red, green, and blue (RGB) or infrared (IR) beams can be emitted and scanned across a field of view (FOV) without the need for bulky collimating optics. The chip-based design allows for significant miniaturization and reduction in complexity of optical systems. This technology is ideal for applications requiring small, lightweight, and energy-efficient beam scanning devices in consumer electronics and sensing systems.

Background

Conventional AR displays and LiDAR systems rely on mechanical MEMS mirrors to steer laser beams. These systems are limited by trade-offs in resolution, beam size, and scanning speed due to physical constraints of MEMS components. Achieving high frame rates, large FOVs, and low divergence beams simultaneously is challenging. Moreover, multi-beam scanning methods typically require multiple discrete lasers, increasing the system's size, cost, and assembly complexity. Additionally, the use of free-space optics makes miniaturization difficult. Current systems are thus not ideal for lightweight, wearable applications or compact mobile sensors. A new approach is required that integrates all optical components on a single chip to overcome these limitations.

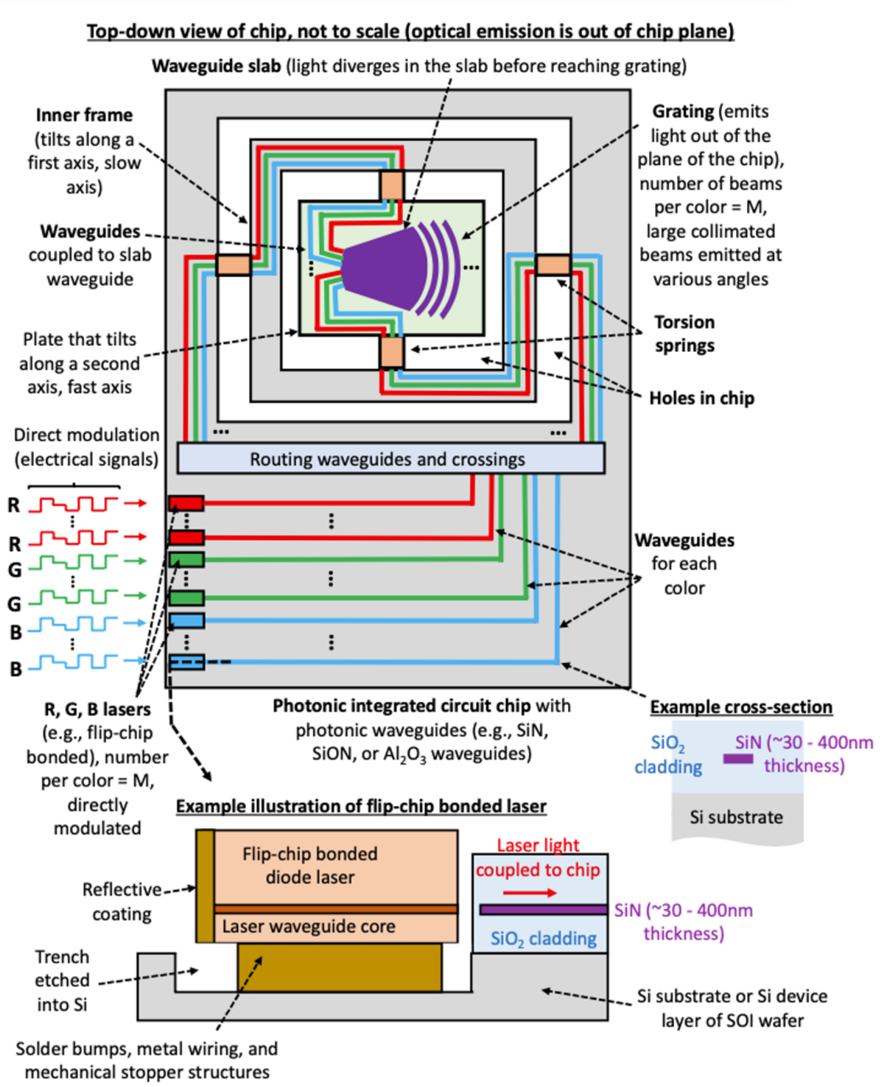

Figure 1: Top-down schematic of the photonic integrated circuit (PIC) with flip-chip bonded RGB lasers, waveguides, and a movable platform for dual-axis beam steering. Light is routed through waveguides into a slab waveguide, expands, and is emitted by an apodized grating into free space. The platform's rotation enables multi-beam scanning for AR display and LiDAR applications.

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The invention centers on a photonic integrated circuit (PIC) that integrates red, green, blue (RGB), and optionally infrared (IR) lasers with waveguides, slab waveguides, and diffraction gratings on a microelectromechanical movable plate. Light from directly modulated on-chip lasers is routed via high-index contrast waveguides to a slab waveguide on the movable plate, where it expands laterally. From there, an apodized diffraction grating emits the light as large-diameter, low-divergence beams into free space. The plate can tilt around two orthogonal axes - fast and slow - using either electromagnetic actuation (via Lorentz force and integrated coils) or piezoelectric actuators. This dual-axis tilt enables precise two-dimensional beam steering at high frequency and low latency.

Multiple subsets of RGB or IR waveguides inject light into the slab at different propagation angles, allowing the generation of multiple independent beams. These beams can be scanned in parallel across distinct slices of the field of view (FOV), significantly improving image resolution and LiDAR point cloud density. The grating design, which may be curved and multi-layered, ensures wavelength-specific beam shaping and emission angles. Optional wavelength multiplexing enables co-axial RGB output per waveguide. The entire system is monolithically integrated, reducing size, power consumption, and packaging complexity. This architecture supports both display and sensing modalities, facilitating multifunctional optical modules.

Advantages

- **Collimated beam emission on-chip**: Produces low-divergence beams without external lenses through integrated slab waveguides and apodized gratings.
- **Two-axis beam steering**: Allows fast and precise scanning across both horizontal and vertical directions using compact actuators.
- **Simultaneous multi-beam output**: Multiple beams can scan different parts of the field of view in parallel, enhancing resolution and speed.
- **Highly integrated and miniaturized**: Combines lasers, optics, and mechanical components on a single chip, reducing size and assembly complexity.
- **Dual-function capability**: Supports both RGB display for AR and IR-based depth sensing for LiDAR within the same chip architecture**.**

Potential applications

- **Augmented reality glasses**: Serves as a compact light engine for high-resolution, low-power near-eye displays.
- **Compact LiDAR systems**: Enables detailed 3D scanning for mobile, automotive, and robotic applications.
- **Integrated AR and sensing modules**: Provides simultaneous visual display and environmental depth mapping.
- **Eye and gesture tracking**: Supports precise detection of user inputs in wearable or interactive devices.
- **Embedded optics in smart devices**: Fits into consumer electronics for advanced imaging or sensing features.

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