

Technology Offer

Integrated Beam-Steering Device for Visible and Infrared Light

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Abstract

This invention provides a compact and integrated photonic device capable of steering light beams in free space without mechanical components. The device is particularly optimized for light in the visible and infrared spectrum, addressing a major limitation of conventional optical phased arrays (OPAs). Through the integration of a waveguide array, phase shifters, a slab propagation region, and a grating array, the system enables precise beam-steering while suppressing unwanted side lobes. This architecture allows for single-lobe emission in challenging spectral ranges and supports integration on standard photonic platforms. Applications include LiDAR systems, augmented reality displays, and biomedical optical stimulation, where precise control over light direction and minimal beam distortion are essential.

Background

Optical beam-steering is crucial in many emerging technologies such as autonomous vehicles and neural imaging. Traditional OPAs are limited in the visible spectrum due to fabrication constraints that prevent suppression of side lobes, resulting in reduced beam quality. Existing solutions often rely on mechanical steering or operate only in the infrared range, which restricts their use in compact and dynamic environments. Moreover, the requirement for sub-wavelength grating spacing poses significant manufacturing challenges, especially for visible light. This invention addresses these limitations by enabling beam-steering within integrated photonics using a novel light manipulation approach.

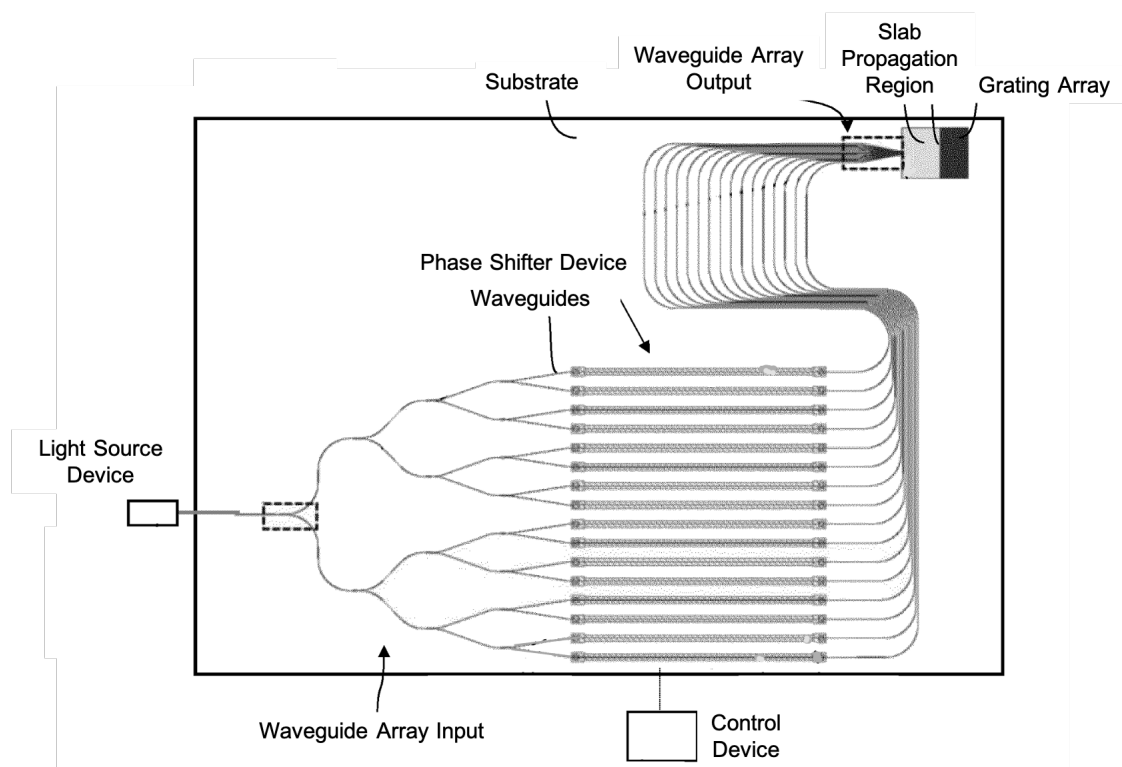


Figure 1: Schematic overview of the integrated beam-steering device architecture. Light is phase-controlled in multiple waveguides, combined in a slab region, and emitted directionally via a grating array.

Technology

The presented beam-steering device is built on a planar photonic integration platform and comprises four key components: a waveguide array, a phase shifter array, a slab propagation region, and a grating output array. Incoming light is introduced via a single input and split into multiple optical paths using a multimode interference coupler. Each path is routed through a waveguide and subjected to a controlled phase shift, allowing for precise manipulation of the optical phase across the array. The waveguides, made from low-loss materials such as silicon nitride, are engineered to support visible to near-infrared wavelengths and are tapered toward a densely packed output interface.

The core innovation lies in the slab propagation region, a passive free-space-like zone where the phase-shifted light waves from the waveguides coherently combine. This structure supports interference-based beam formation: the main lobe is angularly directed toward the output grating, while side lobes diverge and exit the slab laterally, thereby being filtered from the output. A patterned grating array at the output end then couples the well-formed beam into free space, emitting it at a direction determined by the collective phase inputs and optical wavelength.

Optionally, thermal or mechanical actuators can adjust the device geometry to enable steering along a second angular axis, providing two-dimensional beam control without moving parts.

Advantages

- **Non-mechanical beam-steering** for compact and robust systems.
- **Suppression of side lobes** ensures high beam quality and precise targeting.
- **Operable in visible and infrared ranges**, expanding usability across sectors.
- **Fully integrable in photonic chips**, reducing size and manufacturing cost.
- **Dual-axis steering capability** through thermal and structural control mechanisms.

Potential applications

- **LiDAR systems** for compact, high-resolution spatial sensing in autonomous vehicles and drones.
- **AR/VR displays** requiring precise and miniaturized light steering for immersive visual experiences.
- **Neural probes** enabling targeted optical stimulation and readout in brain research.
- **Quantum technologies** using visible light for manipulation of atoms, ions, and molecules.
- **Integrated sensors** in lab-on-chip systems needing directional light for analysis and detection.

Patent Information

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