High-Performance Electro-Optic Beam Steering with Thin-Film Lithium Niobate Optical Phased Array

Narrow Main Beam, Low Side Lobes! High-Performance Electro-Optic Beam Steering with Thin-Film Lithium Niobate Optical Phased Array

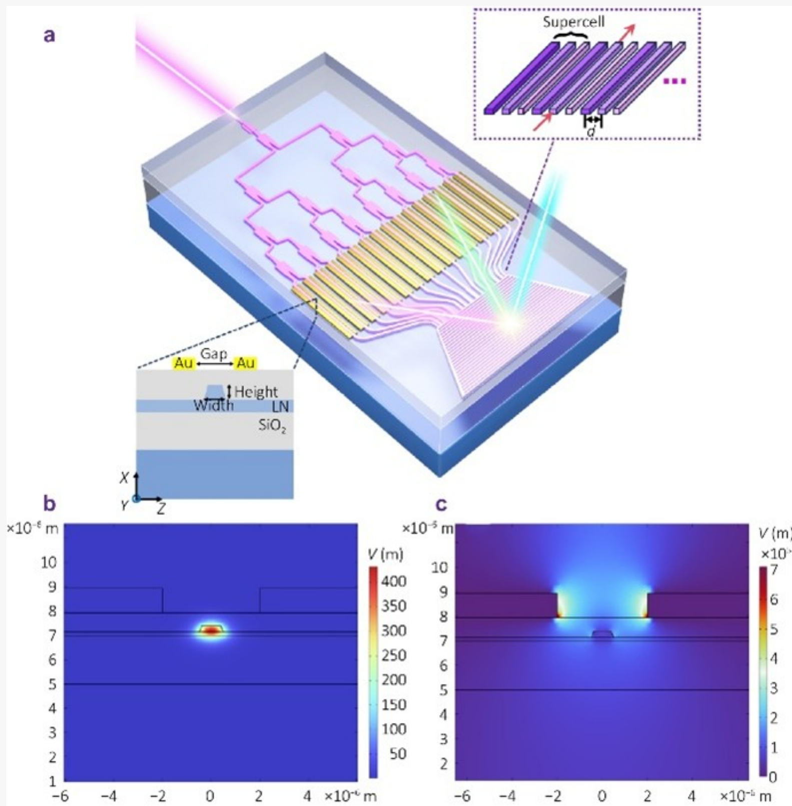

Figure 1. (a) Schematic diagram of the thin-film lithium niobate optical waveguide phased array

SHANNON, CLARE, IRELAND, February 27, 2026 /EINPresswire.com/ -- Announcing a new publication from Opto-Electronic Sciences; DOI 10.29026/oes.2026.260002. Optical beam steering plays a vital role in modern photonics, enabling key technologies such as free-space optical communication, light detection and ranging (LiDAR), and biophotonic manipulation. Compared with traditional mechanical scanning methods, optical phased array (OPA), as a key solution of all-solid-state beam scanning technology, with advantages such as no mechanical inertia, high-speed response, and high integration, has become a current research hotspot. However, the existing integrated OPA technology still faces challenges such as wide main beam, high sidelobes, and limited scanning resolution, which severely restrict its application in high-accuracy and high-signal-to-noise ratio scenarios. In recent years, thin-film lithium niobate has provided a promising integrated photonics platform for solving these bottlenecks due to its excellent electro-optic effect and low optical loss. Nevertheless, achieving both a narrow main beam and low sidelobes simultaneously within a limited aperture remains a long-standing and challenging problem.

To address this issue, the authors of this article propose an innovative thin-film lithium niobate OPA design that enables high-performance electro-optic beam steering with narrow main beam and suppressed sidelobes. This work provides crucial support for the development of chip-scale beam-steering devices in applications such as free-space optical communications and LiDAR.

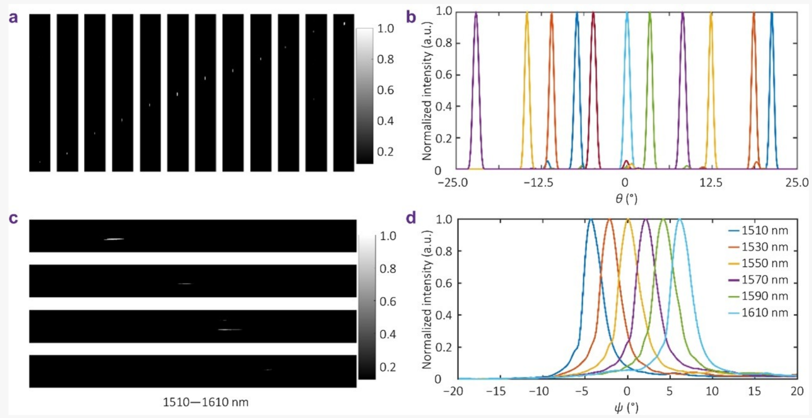

Figure 2. Two-dimensional beam steering of the optical waveguide phased array.

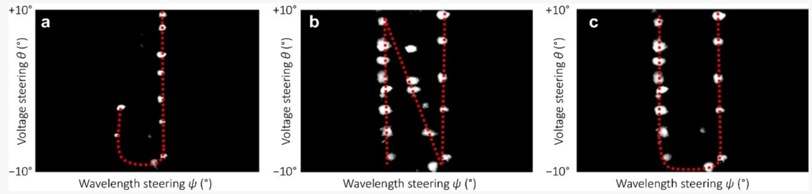

Figure 3. Far-field synthesized pattern forming the “JNU” image by simultaneously controlling the wavelength tuning and the phase modulation.

To address the long-standing challenge of balancing beam quality and steering performance in conventional OPAs, the authors propose and experimentally demonstrate a new electro-optic beam steering scheme based on thin-film lithium niobate. The goal is to achieve a simultaneous breakthrough in narrow beam width and low sidelobes within a compact device footprint.

Leveraging the strong electro-optic effect of thin-film lithium niobate, the research group introduces multiple innovative design strategies to realize a high-performance two-dimensional electro-optic steering OPA. A superlattice ridge waveguide structure is employed to effectively suppress optical crosstalk between adjacent array elements, leading to cleaner far-field radiation. In addition, a non-uniformly spaced array optimized using a particle swarm optimization algorithm is implemented to significantly enhance steering resolution while maintaining effective sidelobe suppression. Furthermore, the integration of a single trapezoidal end-fire radiator with etched gratings enables further compression of the main-lobe beam width under a limited aperture condition. Experimental results show that this 16-channel optical waveguide phased array can achieve a main beam width of 0.99°×0.63° using an optical aperture of only 140 μm×250 μm. At the same time, it achieves a wide two-dimensional steering field of view of 47°×9.36° and a side lobe suppression of 20 dB, demonstrating excellent electro-optic modulation and steering performance of the beam. This achievement not only verifies the effectiveness of the co-optimization of narrow beam, low sidelobes, and wide steering range, but also provides a promising technological pathway toward high-performance, low-power, and integrable beam steering devices.

Keywords: non-uniform lithium niobate waveguide arrays, superlattice waveguide, optical beam steering, narrow beam, low sidelobe

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The research group on optical waveguide hybrid integration and micro-nano optical devices has been deeply engaged in integrated photonics, striving to overcome key technological bottlenecks. Their main research explores light–matter interactions at the micro-nano scale, as

well as the applications of generation, transmission, modulation, detection, and sensing of light. The team has achieved significant results in the research fields of waveguides and micro-nano optical devices, publishing numerous significant achievements in renowned international journals such as Nature Nanotechnology, Light: Science & Applications, Laser & Photonics Reviews, Nano Letters, Research, Applied Physics Letters, Optical Letters, Optical Express, and Photonics Research. Their work has been supported by funding from the National Key Research and Development Program of China, the National Science and Technology Major Project, the National Natural Science Foundation of China, the Guangdong Outstanding Young Scientist Fund, and the Guangdong Special Support Program, among others.
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