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Large-field-of-view and electrically-driven 2D beam steering based on VCSEL scanner array

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1. Introduction

Solid-state beam steering has been attracting many efforts because of its importance to make 3D sensors more practical in size, price, and stability. Non-mechanical beam steering technologies, such as optical phased array (OPA) provide promising opportunities for next-generation solid-state 3D sensing. However, these beam scanning techniques have shown some remaining issues such as insufficient resolution points number and need of widely-tunable external laser sources. In this paper, we proposed and fabricated a counter-propagation-switchable VCSEL scanner to reduce the chip size of previous separate counter-propagation scanners. Then, the 2D beam scanning was realized by assisting with a cylindrical lens, of which the field of view was expanded by 2D DOE.

2. Principle of device and scanning module

The schematic of a counter-propagation-switchable VCSEL scanner and 2D beam steering module based on scanner array are shown in Figs. 1 and 2. The device was composed of a large-angular-dispersion VCSEL waveguide [1] shared by two counter-propagation surface-grating seed VCSELs. When increasing the current injected into the seed VCSEL I_{VCSEL}, the thermally-induced redshift of lasing wavelength will make the emission angle of the shared scanner sensitively scan in the θ direction. Besides, by injecting current into the scanner $I_{scanner}$, the output power from a scanner can be amplified to >3W [2]. The length of tunable seed VCSELs and a scanner are 0.5mm and 2mm, respectively. The 10×7-beam DOE and prism mirrors were placed to enhance the scanning FoV by 10×7 times and make FoV cover vertical direction [3]. The cylindrical lens was used to collimate beam and assist in realizing beam steering in ϕ direction.

2. Experiments

By tuning I_{VCSEL} from 50mA to 210mA and switching 6 scanners in the array one by one, the far-field pattern of the module reflected by a flat target was shown in Fig. 3. The 2D beam scanning field of view of > 70° × 45° was witnessed. The detail of beam divergence in a single order could be measured by an FFP analyzing camera as shown in the zoomed figure. The average beam divergence of all beams in this order is <0.1° × 0.12°. Previously, it was found that beams in all orders had similar divergence [3]. It indicates the number of total resolution points reached > 30,000.

4. Conclusion

We demonstrated 6-counter-propagation-switchable VCSEL scanners array in a 3mm × 3mm chip and realized 2D beam scanning with a large field of view of 70° × 45° assisting with DOE, prism mirror, and a cylindrical lens. It provides record-large resolutions of 30,000 (800×42) without the requirement of an external light source and therefore offers great potential for mm-scale package.

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Reference

[1] X. Gu, et. al, OPEX 19(23), 22675 (2011)
[2] S. Hu, et. al, APEX 14(6), 62005 (2021).
[3] R. Li, et. al, APEX 14(11), 112005 (2021).

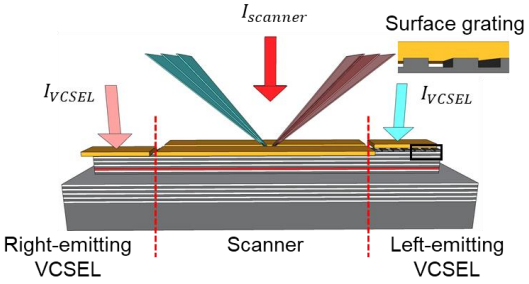

Fig. 1. Sstructure of proposed VCSEL beam scanner

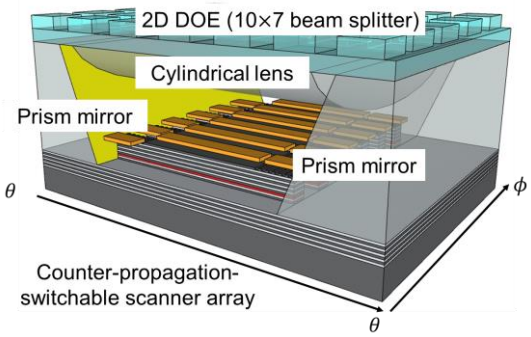

Fig. 2. Schematic of 2D beam scanning module

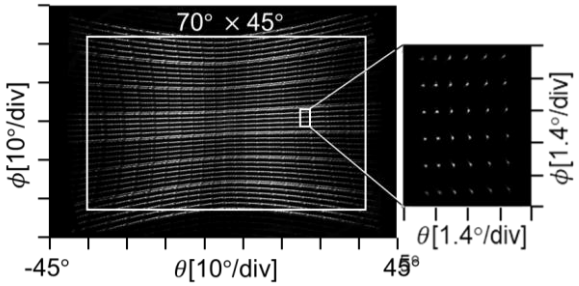

Fig. 3. 2D scanning FFP by free-space measurement