Compact VCSEL beam scanner with large field of view and its 2D scanning function

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1. Background

A solid-state beam scanning technology has been attracting more attention thanks to its key role in 3D sensing, such as LiDAR for automotive or time-of-flight camera for mobile phones. Conventional beam scanners with either MEMS mirror or mechanical mirror is suffering from the problems in long-term reliability and bulky package size. For decades, beam scanners based on non-mechanical technology, such as optical phase array, could make a breakthrough. However, the small scan range, insufficient resolution, and difficulties in integration with light source limit their real applications in 3D sensing. In this paper, we present the solid-state 1D-beam scanner with large field of view and high-resolutions. Also, we demonstrate the electrically-driven beam scanners array to realize 2D beam scanning.

2. Enhanced field-of-view, electrically-driven beam scanner by using 7-spot DOE

The schematic, structure and photo of our beam scanner is shown in Figs. 1 (a). It is composed of a 3.5 mm long beam scanner [1] and a 0.5 mm long tunable slow-light VCSEL [2]. Through changing the injected current into the slow light VCSEL, the lasing wavelength will also be changed. Due to the angular dispersion of the integrated beam scanner, the wavelength variation of coupled light from slow-light VCSEL will lead to the scanning of output beam. The DOE functions to split the original beam emitted from the scanner to 7 fan beams with similar separation of 8°. Varying the current injected into slow-light VCSEL from 50 mA to 350 mA, the lasing wavelength was tuned by 5.8 nm and the beam scanned by 8° as shown in Fig. 1 (b). Therefore, the separation will be fulfilled and hence it makes the field of view 7 times as large as original scan range. In experiment we continuously covered the total range of 56°× 14° as shown in Fig. 2. Because he average beam divergence of these beams is 0.055°. it indicates the total resolution points number of >1018.

2. 2D beam scanning by integration of beam scanner arrays and utilizing cylindrical lens

The 2D beam steering could be realized by integrating a beam scanner array as illustrated in Fig. 3 (a). It could be seen that the 6 scanners were aligned with pitch space of 500 um in the ϕ direction. Through a cylindrical lens the ϕ-direction-large-divergence (>14°) beam could be focused to a spot. Depending on the relative position of a scanner array and lens, the beam steering in the ϕ-direction could be realized. By varying current injected into slow-light VCSEL from 50 mA to 300 mA and switching scanners one by one, the 2D beam scanning of 9°× 6° was obtained as shown in Fig .3 (b). The average beam divergence in θ direction is 0.18°, which indicates the resolution number of 33 × 6.

4. Conclusion

We demonstrated the ultra-compact electrically-driven VCSEL beam scanner with enhanced field of view of 56° and resolution points number of larger than 1000. Through integration of a counter-propagation beam scanner, the field of view and total number of resolution points could be double. We also proposed the beam scanner array cooperated with cylindrical lens to realize 2D beam scanning and successfully demonstrated the 2D beam scanning with field of view of 9°× 6°. It is expected to cover the field of 56°× 50° by integrating more scanners and using DOE as previous session.

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Reference

[1] X. Gu, et. al, Opt. Express 19(23), 22675-22683 (2011).
[2] A. Hassan, et. al, in Conference on Lasers and Electro-Optics 2021, paper STh1G.

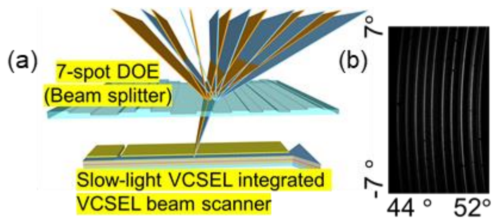

Fig. 1. Principe and original FFP of scanner

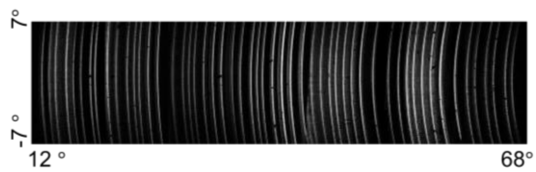

Fig. 2. Measurement FFP result of scanner with DOE

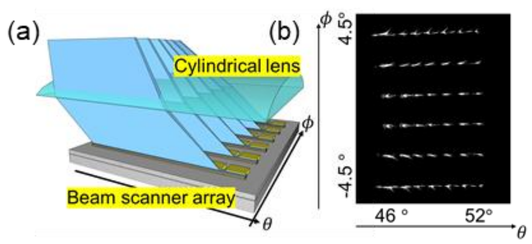

Fig. 3. 2D scanning schematic and FFP result