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Linear MEMS mirror array for long range LiDAR

According to a market report, the global automotive LiDAR market has reached $38 million USD in 2021 and is expected to reach $2 billion USD by 2027 [1]. Adoption of LiDAR in new applications, such as smart infrastructure, logistics, and other sectors, is expected to push the overall market size to $6.3 billion USD by 2027 with a CAGR of 22%. Rapid improvement in LiDAR technologies is required to facilitate the highly anticipated development of autonomous driving. In fact, some of the key attributes of LiDAR modules have seen drastic improvement already, such as a 90% reduction in weight by replacing assemblies of photodetectors with a single-photon avalanche diode (SPAD) array. The industry is eagerly looking to improve several key system attributes such as package size, power consumption, and cost of LiDAR systems to enable level 2+ autonomous driving and beyond, with over 50% adoption in level 3 (hands off) by 2035 [2]. As a result, solid-state technology has drawn large attention because of its advantage in batch processing for scalable cost reduction and excellent component integration ability.

Utilization of linear mirror arrays in non-coaxial systems

To retrieve deeper and more detailed information from the road, more photons returning from the object need to be effectively collected. To this end, the industry is looking to increase MEMS mirror sizes while maintaining laser output to comply with eye safety requirements. There are two system configurations that are commonly used in the design of LiDAR modules - the coaxial system, and the non-coaxial system. Coaxial systems suffer from shadowing effects due to placement of the laser and detector on the same optical path and are highly dependent on the steering mirror size[3]. Non-coaxial systems have more flexibility in the transmitting subsystem because the beam quality and size can be highly optimized before hitting the scanning MEMS mirror. Additionally, the collection optical aperture is not limited by the scanning mirror size. As a result, the size of steering mirror used for transmission can be greatly reduced to improve cost and mechanical dynamic performance. For the receiving end of the non-coaxial LiDAR system, a large mirror is then required to capture as many photons as possible to extend detection range.

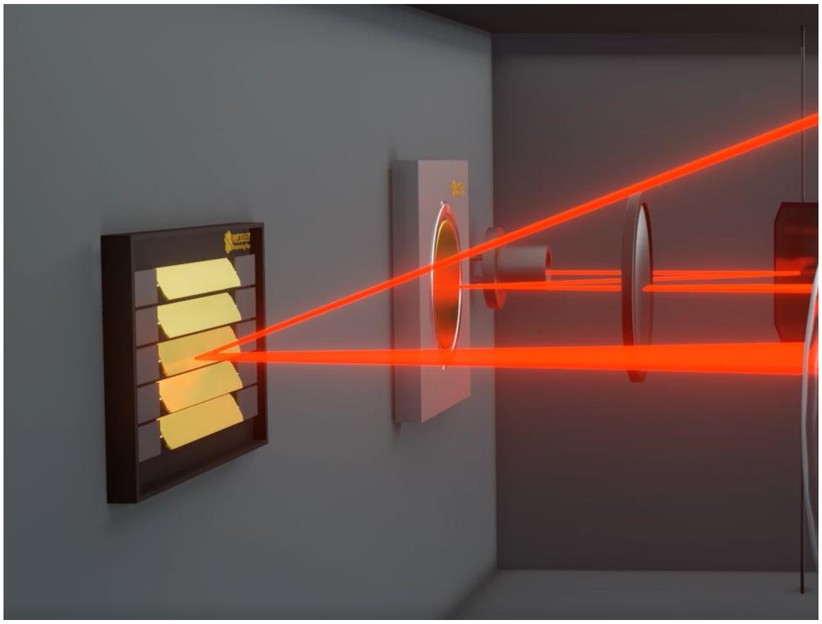

Figure 1. Illustration of a linear MEMS mirror array integrated inside a non-coaxial optic system

The difficulty of making a larger, heavier object move faster is readily apparent. Stiffer supporting and restoring structures are needed to compensate for the additional weight and inertia, while maintaining a high resonant frequency (and thus speed). A larger actuating force is required to overcome the stiffened spring to drive the mirror to high angles. Instead of working with one large mirror, an array of smaller mirrors is designed that can produce higher tilting angle and be driven faster. This allows the MEMS mirror to reach over ~7mm in effective aperture as demonstrated in Table 1. With a series of MEMS mirrors moving synchronously, the reflected light from a target can be captured by each individual mirror and routed to the receiving detectors. Thus, reduced crosstalk and higher efficiency is achievable with PMC MEMS mirror arrays. When combining with a linear avalanche photodiode (APD) or SPAD array, two-dimensional mapping with the LiDAR system can easily be realized [Fig. 1]. This new approach which redistributes the weight of a large mirror into an array of individually addressable, individually supported mirrors, results in superior robustness and shock/vibration tolerance. The smaller mirrors are also less susceptible to material and air damping resulting in low dynamic deformation at high velocity. Additionally, the overall aperture of the MEMS mirror array can be further increased by increasing the number of mirror elements in the array without compromising other critical parameters.

Parameter	Condition	Unit	Specification		
			Min	Typical	Max
Array size	Ribbon Mirror	*n/a*		14	
Overall aperture		*mm*		7x6	
Reflectivity	1530 – 1625 nm (Metal reflector: Au thin film coating)	*%*	90		98
Power Handling		*mW*			500
Max. mirror mechanical tilt angle	X axis	*deg.*			+/-8.0
Durability	Hermetic sealed	*Cycle*		10^9	
Operating temperature		*°C*	-40		105
Storage temperature range	5% humidity	*°C*	-40		85

Table 1. Linear MEMS mirror array specification

Preciseley's MEMS products are designed for reliability and volume manufacturing

Our MEMS mirrors are highly optimized for stability and repeatability with an absolute minimum of crosstalk between adjacent mirror structures. They also feature an extremely high fill factor in excess of 95%, with fixed or variable mirror pitch, a mirror length up to 1 mm or more, and 1-axis or 2-axis tilting. Preciseley are experts in design and manufacturing of high-performance MEMS mirrors for telecom/datacom and industrial applications, with nearly two decades of experience in high volume MEMS mirror production and millions of units shipped. Our mirrors are widely deployed in applications with demanding shock, vibration and lifetime reliability requirements. We understand the importance of design for manufacturing, having delivered high performance and high-quality products worldwide for over 16 years.

References:

[1] P. Boulay, A. Debray, " LiDAR 2022 – Focus on automotive and industrial Product Brochure" Yole Product Brochure.

[2] B. Weiss "SEMI and Yole Development Present: Smart Automotive – Latest Trends in LiDAR and Sensors" 2017

[3] J. Harms "LiDAR return signals for coaxial and noncoaxial systems with central obstruction" Applied optics Vol.18 No. 10 1566 (1979.