Pure Solid State Scanning Lidar based on 2D VCSEL array

Do you remember your first digital camera? If you are younger than 20, you might have never used a film camera outside of your high-school photography class. For those older, your first digital camera probably had 640x480 resolution (300k pixels) and could store only a few still images on the internal memory. Today, most of us carry phones with multiple camera sensors, each exceeding several megapixel, and HD video capability is a given. Semiconductor image sensors have followed a Moore's law like growth curve resulting in enormous advances in capability while keeping costs low.

Opsys believes LiDAR systems based around semiconductor array components, with a "pure" solid state architecture (e.g. no-moving parts) will follow a similar innovation path. Since our inception in Jan'2016, we have exclusively worked on pure solid-state scanning LIDAR using 2D VCSEL (vertical cavity surface emitting laser) array, developing a unique architecture that overcomes the range limitations of traditional wide-area Flash. With over 14 patent filings so far, our architecture combined with state-of-the-art semiconductor components sets a new bar for range, resolutions, and size while also establishing a platform for the future.

VCSEL have been used for 20+ years for optical communication, enabling low-cost, high-volume transceivers. In the last 5 years, they have become common components inside cell phones for 2D sensing, at volumes exceeding 100M+ lasers/year. Short-reach VCSEL based Flash LIDAR sensors have also been introduced recently into consumer handheld devices. Automotive will be a 3rd wave for VCSEL production; compared to today, the total volume of VCSEL wafers manufactured per year will more than double within a decade, making automotive VCSEL the largest volume market for VCSEL. The substantial volume growth will drive lower costs, and continued R&D which will directly benefit LiDAR systems based around 2D VCSEL array.

Why do we use VCSEL? First and foremost, we use VCSEL because we can build a high performance, cost-effective system with thousands of lasers using a monolithic semiconductor array. VCSEL are smaller, more reliable, simpler to fabricate, more power efficient, and easier to integrate then edge-emitting laser technologies. VCSEL can be built into 2D monolithic arrays at high-volume using the same consumer grade chipmaking fabrication technology as CMOS image sensors. The VCSEL we use operate in the wavelength range of 850nm to 980nm which makes them compatible with Silicon based detector arrays, which are much lower cost then detector arrays designed for wavelengths in the 1550nm range.

VCSEL also don't require the expensive hermetic packaging that some edge-emitting lasers require. As well, a LiDAR system using VCSEL and SPAD can support much higher operating temperatures then the mechanical or MEMS's LiDAR systems available today based on edge emitter lasers. Both SPAD and

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VCSEL devices have been demonstrated that can operate at chip temperatures of over 100°C, which gives adequate margin for a LiDAR system that is specified to ≥ 85°C case temperatures.

How are the VCSEL that Opsys uses for LiDAR different? A VCSEL developed for optical communication emits ~5 to 10 mW per laser at a roughly 50% duty cycle. We require VCSEL lasers that emit 50 to 100W (1000x the optical power) but fortunately at a duty cycle on the order of 0.05% (1000x lower duty cycle). Recent innovations have enabled a significant increase in VCSEL brightness, such that lasers meeting the required optical powers are becoming increasingly common. These higher brightness lasers allow us to operate at a transmitter optical power density that enables ranges of 200m or more. Traditional broad field-of view (FOV) flash systems have significantly lower optical power density, and those wide FOV systems are typically limited to less than 50m because of eye safety concerns.

The VCSEL inside the Opsys systems are 2D monolithic VCSEL array on the order of a few mm in size. We also are the first in the industry to productize a matrix-addressable (MA) array for LiDAR. An MA array has anodes and cathodes arranged in a row-column fashion, which allows an individual laser within the array to be turned on/off and minimizes the number of laser drivers needed to operate the array. The MA VCSEL arrays topology combined with our unique laser driver topology (Opsys proprietary), enables a scanning system with no moving parts, lower cost, smaller size, and performance features that cannot be implemented with the traditional “common cathode” arrays.

The Opsys system designed with high-brightness, MA VCSEL and integrated with other custom hardware, has the ability to scan the environment and measure beyond 200m, while maintaining eye safety. We do this by projecting beams with tight enough FOV to stay below the eye safety limit, but with high enough optical power density to enable the longer ranges, along with other system level innovations.

In production volumes, the OPSYS LiDAR system will utilize millions of laser arrays and SPAD based image sensors. Working together with semiconductor device suppliers that have demonstrated ability to scale and deliver at high-volume, coupled with Opsys unique Lidar technology enables the delivery of world class scanning Lidars , at costs and performance that will displace traditional Lidar systems requiring mechanical scanning.

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