Fraunhofer Institut Photonische Mikrosysteme

Lamda – Large aperture MEMS scanner module for 3D distance measurement

Traditional laser scanners for 3D distance measurement involve expensive, heavy and large rotating or vibrating mirrors as a means for light deflection of the scanning TOF (time of flight) distance measurement. Typically, the precision of TOF distance measurements is limited by the amount of signal light available at the detector. Hence, a scanning mirror with large aperture is required for LIDAR systems to collect small amounts of light reflected or scattered by the measured target. Its replacement by a micromechanical scanning mirror device is not straightforward, since a large mirror aperture of the receiver optics must by guaranteed in addition to sufficiently large optical scan angles (> 40°) and high scan frequency of more then 100 Hz. Contrary, the aperture of a single MEMS scanning mirror is limited to small values of typically 1…4 mm diameter due to the dynamic mirror deformation.

The Fraunhofer IPMS has developed so far highly miniaturized MEMS scanner devices enabling significant large deflection amplitudes (up to ±35°, mechanical) and low power consumption in electrostatic resonant operation, very promising for miniaturized and portable applications. Customized 1D/2D scanner devices are fabricated from single crystalline silicon in a qualified fully CMOS compatible MEMS process suitable for mass fabrication resulting in highly robust and reliable MEMS devices that withstand easily a shock of 2500 g.

Now the Fraunhofer IPMS presents for the first time the prototype of a new large aperture 1D MEMS scanner module especially designed for laser radar systems. The Lamda module is constructed based on a novel MEMS array of identical scanning mirror elements realized using the flexible MEMS technology of Fraunhofer IPMS. Therefore, Fraunhofer IPMS has designed a scalable MEMS scanner array composed of identical silicon mirror elements each having a comparatively large aperture of 2.51 x 9.51 mm² and a large optical scan range of ±30°.

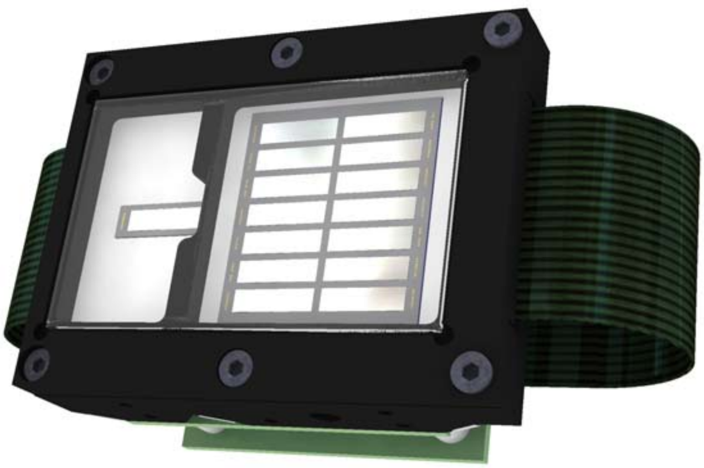

Fig. 1: MEMS scanner module (scan head) with transmission beam scanner (left) and receiving scanner array (right)

Fraunhofer-Institut
Photonische Mikrosysteme

Maria-Reiche-Str. 2
01109 Dresden
Phone: +49 (0) 3 51/88 23-0
Fax: +49 (0) 3 51/88 23-266
www.ipms.fraunhofer.de

Contact:
Ines Schedwill
Phone: +49 (0) 3 51/88 23-238
ines.schedwill@ipms.fraunhofer.de

Technical questions:
Dr. Thilo Sandner
Phone: +49 (0) 3 51/88 23-152
thilo.sandner@ipms.fraunhofer.de

The 1D MEMS scanner module comprises two separate scanning channels: (a) a single scanning mirror of the collimated transmitted beam oscillates parallel to (b) a scanning mirror array of the receiver optics. Light paths of emitting and receiving optics are separated to reduce crosstalk in the final laser radar system. The receiver optics use an array of 2 x 7 identical mirror elements resulting in a total aperture of 334 mm² and filling factor of 80%. All mirrors are driven electrostatically resonant at 250 Hz by means of separate in-plane comb drives with identical frequency close to the mechanical resonance for oscillation around their long symmetry axes. Thus, the transmitted beam is sent via a separate emitting master mirror of the same mechanical dimensions as one element of the mirror array. Since laser energy is emitted in only one direction, all the receiving mirrors are synchronized to the master scanner by the driving control electronics to point in the same direction. Hence, the effective apertures of the receiving mirrors add up to form a sufficiently large aperture if all receiving mirrors are synchronized in phase to the emitting master mirror in order to maximize the optical signal of the detector system. To realize the mirror synchronization, miniaturized position sensors are integrated into the Lamda module for each individual mirror element. Thus, a precise control of the mirror motion is achieved so that all receiving mirror elements can be slaved to the motion of the emission mirror. The Lamda scanner module has a total size of about 40 x 52 x 45 mm³ and provides a synchronous position signal of the actual scan angle required for the final 3D laser radar system.

The MEMS array satisfies at the same time the demand of a comparatively large optically active area, 2.51 x 9.51 mm² per single mirror element, while keeping the resonance frequency of 250 Hz at a value that matches well to current TOF laser distance measurement systems with point measurement rates of typical 250 - 1000 kHz. Thus, the optical scan range of ±30 degrees is split into 500 - 2000 intervals.

The new concept of using an array of synchronized identical MEMS mirror elements for LIDAR systems permits large reception apertures while preserving the outstanding reliability, high scanning speed, compact size and small system weight that can be expected from MEMS. In comparison to systems with conventional scanner components, the new 1D MEMS scanner module enables 3D LIDAR systems to become significantly smaller and more robust, higher scan rates can be realized without additional efforts (e.g. air bearings). Hence, the Lamda module is very promising for many applications e.g. in security, machine vision and even for portable outdoor use.

Parameter	**Min**	**Typ.**	**Max**	**Unit**
Scan head form factor (w/o flex connectors)		40 x 52 x 45		mm³
Electronics form factor		80 x 55 x 27		mm³
Optical interface		Window, Broadband AR coating (VIS) 1.5° tilted		
Scanner frequency		250		Hz
Deflection angle (mechanical)	±9.7		±15	°
Optical field of view	39		60	°
Single scanner active area		2.51 x 9.51		mm²
Scanner array total aperture		334		mm²
Scanner array fill factor		80		%
Interfaces		Display, USB, hardware interface (SPI+ proprietary I/O)		
Supply voltage		12		V
Power consumption		2.2		mW

Tab. 1: System parameters of MEMS scanner module