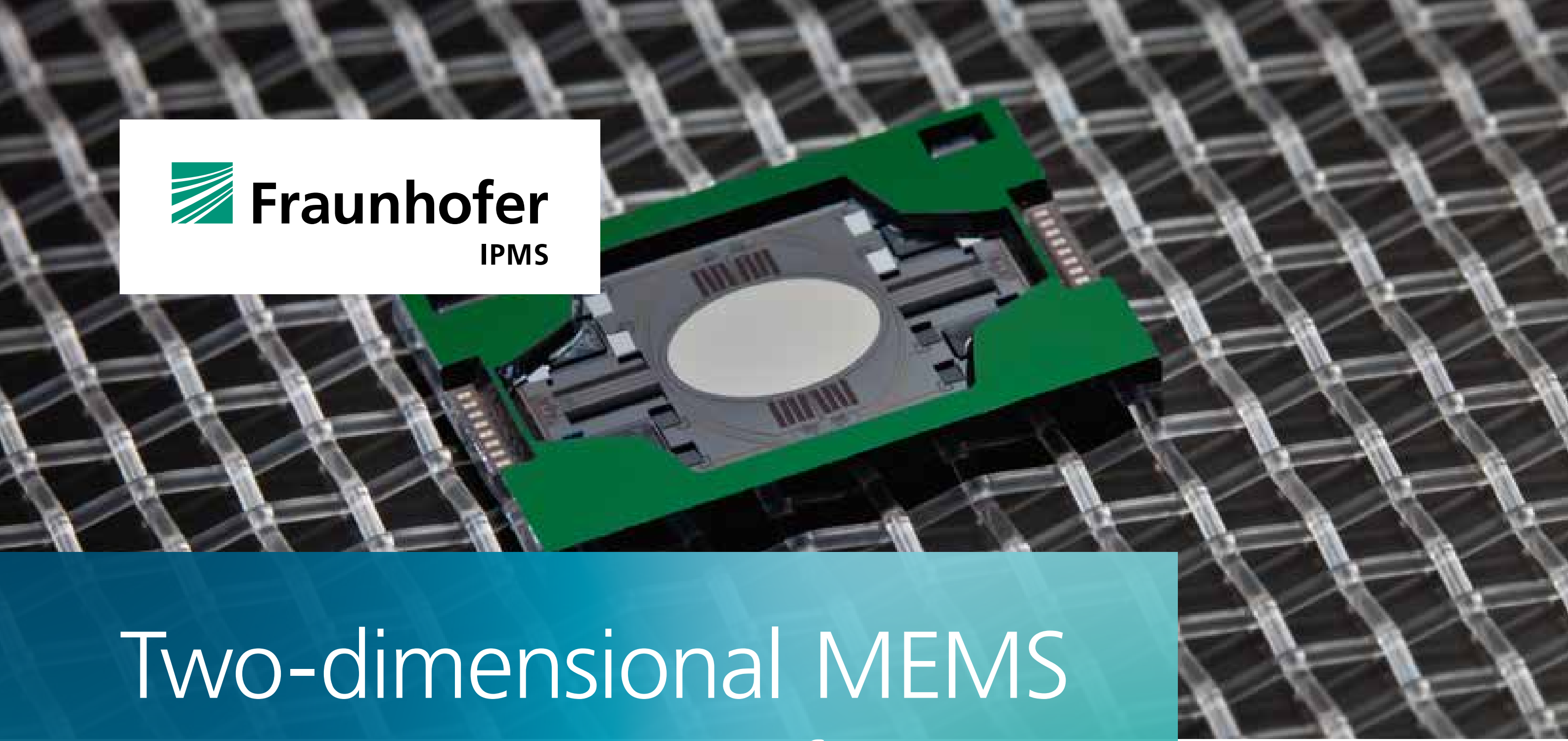

Quasi-static / resonant 2D LinScan microscanner demonstrator.

Two-dimensional MEMS scanning mirrors for security and robotics

Due to the quasi-static drive principle of Fraunhofer IPMS' innovative LinScan scanning technology, it is now possible to dynamically adjust the position and speed of the scanning procedure to switch between target positions quickly andtherefore adaptively control the recording of image information according to the surrounding conditions. 3-D cameras that are equipped with this technology offer a higher resolution locally and can help nextgeneration robots to better comprehend their environment and see more clearly.

Motivation

The broad field of service robots is a dynamic, fast-growing market: Robots are in constant demand when a job poses safety and health dangers to human beings, is too awkward or complicated, or simply more economical or convenient than it would be if it were man-made. In order for the robots to be able to perform such complex tasks independently and reliably, however, the robots have to not only see, but also be able to interpret their environment on their own and be able to control their sight according to the surrounding conditions.

This depends upon the premise that their environmental visualization functions similar to the way the human eye works, i.e. that the sharpest area of sight (Fovea) is concentrated upon objects within our surroundings that we perceive as interesting or important. With the LinScan scanner architecture, Fraunhofer IPMS offers a scanning technology for 3D cameras that imitates human vision by enabling the robot to scan its surroundings and analyze interesting objects with greater precision.

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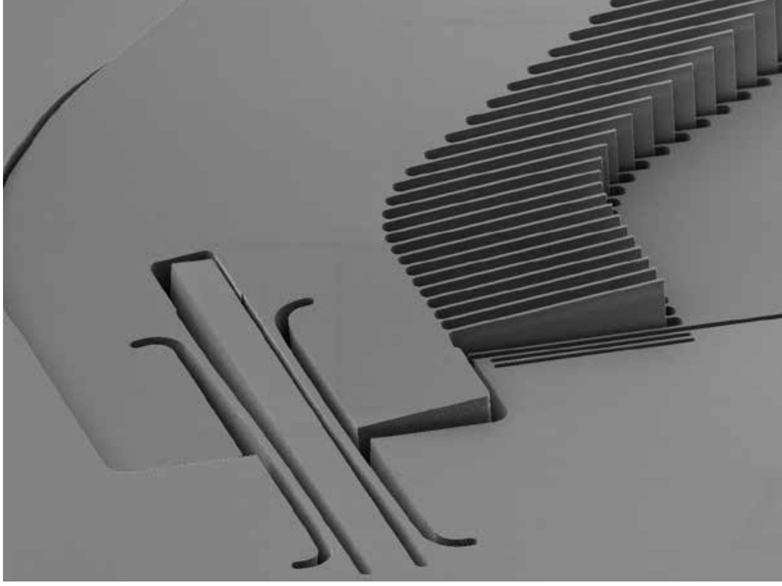
Optical scan head of a 3D-TOF camera with integrated MEMS scanning mirror array.



Vertical comb drive (CAVC)

The LinScan Technology

The LinScan component concept stands for two-dimensional moveable, monolithic MEMS scanning mirrors that combine a resonant drive with a defined frequency in the fast horizontal axis with variable quasi-static deflection on the vertical axis. This makes imaging with a flexible scanning speed, and therefore scanning with adjustable resolution, possible.

LinScan is based on the technology developed by Fraunhofer IPMS for resonant microscanners. The components are manufactured in the in-house cleanroom in volume micro-mechanical manufacturing process on a BSOI substrate. All of the micro-mechanical components are produced as two-dimensional structures in a layer of monocrystalline silicon. In an adhesive wafer bonding process with a second planar-structured silicon wafer, the vertical chamber electrodes are manufactured with a deflection from the substrate and subsequent wafer-bonding fusing. Here the vertical drive electrodes are directed through mechanical solid state mechanisms, satisfactorily mechanically isolated from the manufacturing tolerance, and thus aligned exactly to each other. The component concept is extremely flexible and makes it possible to realize a broad spectrum of component characteristics.

Security Applications and Robotics

In order to implement the fovea principle – i.e. the rough scanning of objects that appear in the field of vision – for security applications, the recognition of the scanned objects, as well as the perception of these objects with a higher resolution, Fraunhofer IPMS has been working on the development of an innovative camera system together with four further research entities and two enterprises from the industry as part of the European joint research project "TACO". Along with the LinScan scanning technology, the researchers are utilizing three-dimensional object surveying based on time of flight (TOF) as well as software for ultra speed object capture and increasing the understanding of the environmental comprehension.

The optical scanning head is made up of a MEMS scanner array which consists of five synchronically operated LinScan mirrors in order to ensure the necessary reception aperture of the TOF distance measurement system of effectively 5 mm. The array has been designed for an adaptive 3D camera system with a minimum 40° × 60° optical scanning range, a 1 MVoxel / s measurement rate of the TOF distance measurement system, and a 3 mm measurement uncertainty at a measurement distance of 7.5 m. The quasi-static drive of the microscanner makes line-by-line imaging with a variable image repeat rate of < 1 - 100 Hz possible, whereby the concentration of the vertical measurement point in the relevant image area can be locally increased by decreasing the scanning speed. The horizontal image recording with cardanically mounted 1.6 kHz resonant micro-mirrors ensures a larger reception aperture in comparison to a 2D quasi-static drive and thus a higher resolution of the TOF distance measurement at the same optical scanning angle of up to 80°.

Sample Component Characteristics of a 2D LinScan Microscanner

- Mirror diameter: 2.6 x 3.6 mm aluminium silvering
- Reflectivity: 88% to 92% in the visible wavelength range
- Static planarity: radius of curvature > 5 m
- Dynamic planarity: ≤ λ / 10
- Integrated Piezo-resistant position sensor system

Quasi-static Drive Axis:

- Scanning frequency: DC - 0.125 kHz
- Static mechanical deflection angle: ±10° @ 150 V

Resonant Defection Axis

- Scanning frequency: 1.6 kHz
- Nominal mechanical deflection angle: ± 15° (20°) @ 160 V

Characteristics can vary according to customer specifications.