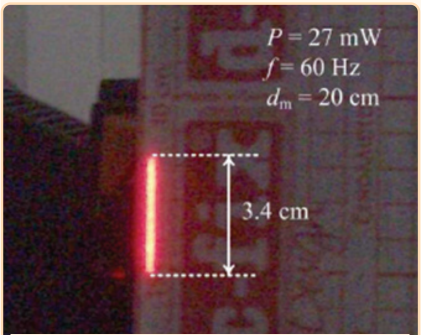
NiFe Biaxial Magnetic Scanner for 2D Imaging
A Successful Case of Academic-Business Cooperation

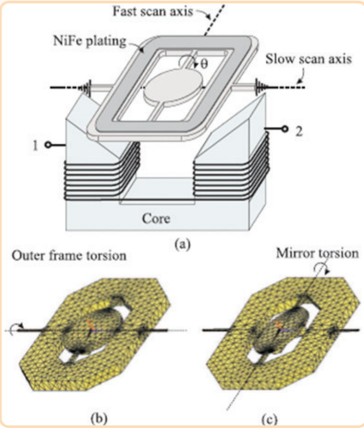
In earlier research a moving coil, Lorentz type device biaxial microscanner, was developed, tested and characterized in cooperation between The Optical Microsystems Laboratory (Koc University, Istanbul, Turkey) and Microvision Inc. (Seattle, USA)[1]. The device showcased world leading performance for 2D silicon based microscanners. Based on this device the first biaxial microscanner was developed and presented.[2]

This device is operated via a magnetostatic torque produced by the combination of a AC flux from a custom made electro coil and a NiFe layer deposited on the movable part. The device is in atmospheric pressure capable of full optical scan angles of 88° (at 100 mA RMS coil current) and 1.8° for slow and fast scan directions, respectively. In combination with a mirror size of 1.5 mm, resulting $\mu_{opt}D$ products are 132 deg·mm and 2.7 deg·mm for slow and fast axis, respectively. As a result a display or part of a display with the present device with 2000×50 resolution can be achieved in ambient pressure, eliminating the need for expensive vacuum sealed packaging.

The Device: The earlier device is a Lorentz type device, driven by a moving copper coil placed on the outer frame, encircling the mirror. When placed in a static magnetic field and if the coil is fed with two superpositioned signals this allows for a 21kHz resonance movement in one direction (fast scan) and sawtooth movement at 60Hz (slow scan) in the orthogonal direction. The device is composed of a circular mirror, gimbal mounted to an outer frame. The outer frame is anchored to a fixed substrate through a set of springs. To be able to instead make use of an external coil the flat copper coils on the outer were electroplated with NiFe alloy.



1-D Scanline created by the device at 20 cm away from the mirror when driven with 60 Hz sinusoidal current.



Magnetostatic Actuator Operation

When an alternating current is passed between the ports 1 and 2, (see figure) a frequency dependent magnetic field (and flux) is created in the direction normal to the scanner plane. The slow scan, consisting of rocking of the outer frame around its hinges, has a resonance frequency at 367Hz. The high amplitude of the fast scan resonance is due to the quality factor of the fast scan. The outer frame makes a small rocking motion parallel with its own hinges, the amplitude of which is multiplied with the quality factor of the mirror to create its much larger deflection. It is worth remembering that the high quality factor of each mode separates the slow and fast scan motions by suppressing all the other spurious drive components because of the strong built in mechanical band-pass filters. This allows for actuation of the two orthogonal scanning modes using only one coil fed with two super positioned sinus signals.

Conclusions: In cooperation between Microvision and Optical Microsystems Laboratory a novel microscanner actuation mechanism is presented to satisfy the performance requirements of the raster scanning mirrors. Several advantages are inherent in the design: Vacuum packaging is not necessary, enhancing cost as well as productivity yield. Resonant operation of the scanner allows filtering out the nonlinearities and hysteresis in the excitation torque. Fabricated using bulk micromachining process, the present device is immune to the dynamic deformation and surface quality problems. There are a number of applications where the present device can directly be used and there is also room for improvement, since the silicon scanner used was originally fabricated for a different actuation method.

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References: **[1]** Arda D. Yalcinkaya, Hakan Urey, Dean Brown, Tom Montague, and Randy Sprague, Two-Axis Electromagnetic Microscanner for High Resolution Displays, Journal of Microelectrochemical Systems, vol. 15, no. 4, pp. 786-794, 1996

[2] Arda D. Yalcinkaya, Hakan Urey, Sven Holmstrom, NiFe Biaxial Magnetic Scanner for 2D Imaging, Photonics Technology Letters, vol. 19, no. 5, pp. 330-332, 2007

Micro Electro Mechanical Systems Laboratory -BUMEMS, Bogazici University

New laboratory in Bogazici University. The initial focus of the lab is on polymer microfabrication and its applications to MEMS and electronic circuitry. Examples of subjects of interest are Soft Lithography, (especially MicroContact Printing) microfabrication with piezoelectric as well as conducting and semi-conducting polymer materials. The traditional MEMS needed are designed using state of the art software, while the fabrication is done off site.

Equipment and capabilities: As of today the laboratory is equipped for 30 µm lithography, SU-8 microfabrication, PDMS Soft Lithography, patterning thin Ni/Cu electrons on PVDF film and patterning of ITO coated PET. Among the equipment that will arrive later is a RIE (Reactive Ion Etcher).

Team: two faculty members, three graduate students and two undergraduate students.

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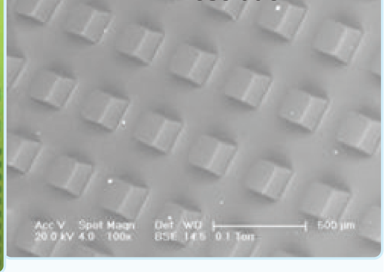
PDMS mold formed from a SU-8 master

Lithography with 30µm resolution.



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