Three-Dimensional Scanner Fabrication

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Principal Investigator: David L. Dickensheets
User: Tianbo Liu

Affiliation: Electrical and Computer Engineering Department, Montana State University

Primary Source of Research Funding: National Institutes of Health
Contact: davidd@montana.edu, tianbo.liu@msu.montana.edu
Website: http://www.montana.edu/ddickensheets/
Primary CNF Tools Used: Photolithography, plasma etching, electron beam evaporation wet chemical processing

Abstract:

A three-dimensional (3D) micro-electromechanical scanner that is capable of providing biaxial scanning and focus control is constructed. The scanner serves as the optical engine in a miniaturized handheld confocal microscope for the non-invasive, *in vivo* detection of skin cancer.

Introduction:

The standard method of diagnosing suspicious growths on the skin is to perform a biopsy. However not only can biopsies be painful and cause permanent scarring, they are also a sparse sampling [1,2]. It would be impractical to prescribe a biopsy for each site that looks suspicious, which leaves room for some malignant cells to go unnoticed. The good news is that a new, non-invasive method called optical biopsy is on the horizon. One of the promising types of optical biopsy is confocal laser scanning microscopy, which uses a laser to image cells under the surface of the skin [3,4]. The problem is that current confocal microscopes are too big, making it difficult to image sites that are in hard-to-reach parts of the body. A microelectromechanical system (MEMS) scanner has been constructed to address this problem by replacing the cumbersome mechanical scanning and focus elements in the conventional confocal microscope with a single 10 mm device [5,6].

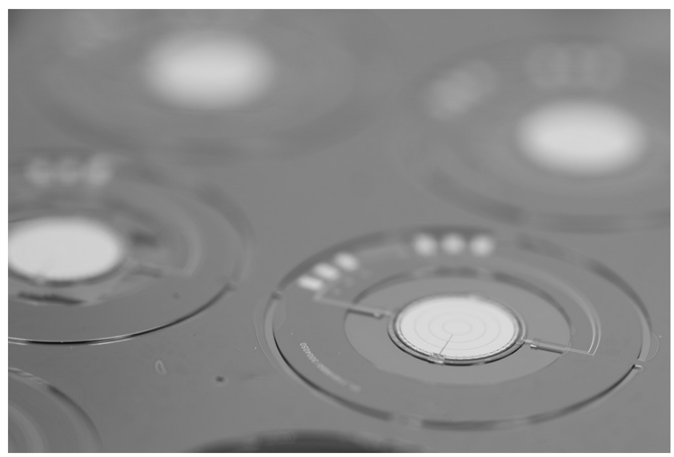

Figure 1: Image of wafer after fabrication. See the full color version on the cover of this book!

Summary of Research:

The device is based on a dual axis gimbal platform that is supported by polymer hinges over a set of quadrant electrodes. At the center of the dual-axis gimbal platform is a deformable mirror that can be actuated independently using its own set of concentric electrodes. The gimbal platform along with a deformable mirror is constructed using a silicon-on-insulator (SOI) wafer, while the quadrant electrodes for scanning actuation are fabricated on a double-sided polished (DSP) silicon wafer. The fabrication process includes the making of the deformable structure, the optical surface, the electrical connections and the polymer hinges. These are completed using microfabrication techniques such as photolithography, plasma etching, electron beam evaporation and wet chemical processing. The quadrant electrodes on the DSP wafer are fabricated using similar techniques. The two wafers are then aligned and bonded.

The release of the device uses procedures including xenon difluoride etching with the Xactix etcher to remove the device layer silicon from the SOI. Low power oxide etching employing the Oxford 81 etcher is used to remove the buried oxide layer. Figure 1 provides a picture of the completed wafer.

Conclusions:

In conclusion, we have fabricated a new polymer enhanced MEMS scan mirror that is capable of high-resolution imaging with simultaneous focus adjustment. The device is geared towards the miniaturization of confocal microscopes for a new generation of handheld optical biopsy devices. It can also be adapted to benefit a wide range of optical imaging and display applications.

References:

[1] G. Argenziano, et al., Accuracy in melanoma detection: a 10-year multicenter survey," Journal of the American Academy of Dermatology, vol. 67, no. 1, pp. 54-59. e1, 2012.

[2] I. Kovalyshyn, S. W. Dusza, K. Siamas, A. C. Halpern, G. Argenziano, and A. A. Marghoob, "The impact of physician screening on melanoma detection," Archives of dermatology, vol. 147, no. 11, pp. 1269l-1275, 2011.

[3] A. Gerger, et al., "*In vivo* confocal laser scanning microscopy of melanocytic skin tumours: diagnostic applicability using unselected tumour images," British Journal of Dermatology, vol. 158, no. 2, pp. 329-333, 2008.

[4] P. Guitera, et al., "The impact of *in vivo* reflectance confocal microscopy on the diagnostic accuracy of lentigo maligna and equivocal pigmented and nonpigmented macules of the face," Journal of Investigative Dermatology, vol. 130, no. 8, pp. 2080-2091, 2010.

[5] T. Liu and D. L. Dickensheets, "Three-Dimensional beam scanner for a handheld confocal dermoscope," in Optical MEMS and Nanophotonics (OMN), 2016 International Conference on, 2016, pp. 1-2: IEEE.

[6] T. Liu and D. L. Dickensheets, "MEMS 3-dimensional scanner for handheld confocal microscope," in Optical MEMS and Nanophotonics (OMN), 2017 International Conference on, 2017, pp. 1-2: IEEE.