Comment on “MEMS-based high speed scanning probe microscopy” [Rev. Sci. Instrum. 81, 043702 (2010)]

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Comment on "MEMS-based high speed scanning probe microscopy" [Rev. Sci. Instrum. 81, 043702 (2010)]

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In a recent article, Disseldorp *et al.* [Rev. Sci. Instrum. **81**, 043702 (2010)] present a micromachined z-scanner for scanning probe microscopy (SPM). The scanner comprises a micromachined electrostatically actuated membrane anchored to its substrate with crab-leg flexures. This structure is used as a fast actuator specifically for atomic force microscope and scanning tunneling microscope. The authors present topographic images acquired using the scanner in this paper and elsewhere [F. C. Tabak *et al.*, Ultramicroscopy **110**, 599 (2010)]. Although the work is clearly described, it does not appear to be placed in proper context. For example, the authors claim that previous work on microelectromechanical systems SPM has not been focused on high-speed imaging with feedback, which is not supported by the existing literature. In addition, similar actuator structures, albeit slightly larger scale, have been designed and used for SPM applications. Here, we would like comment briefly on the existing literature to clarify the significance of the work. © *2010 American Institute of Physics.* [doi:10.1063/1.3499232]

A micromachined membrane-based probe with integrated electrostatic actuator and integrated diffraction-based optical interferometer was introduced for atomic force microscope (AFM) applications in 2005.[1] The resonant frequencies of the devices are larger than 500 kHz and they were coupled with AFM cantilevers in a setup similar to the one in Disseldorp *et al.*[2] and Tabak *et al.*[3] The initial structures were circular membranes made of aluminum. As a natural extension, sharp tips were grown on top of the membranes using focused ion beam assisted deposition. The use of these probes, which were integrated to a piezoscanner has been already demonstrated for fast tapping mode imaging with feedback in 2006 (Ref. 4) and for quantitative material characterization in 2008.[5] On a separate path, similar structures have been used for actuating AFM cantilevers for biomolecular force spectroscopy.[6,7] These micromachined actuators have been shown to have high bandwidth in air (resonant frequency of ~1 MHz) and in fluid (resonant frequency of ~400 kHz). Consequently, the use of these structures as sample holders for fast imaging applications in fluid was proposed.[6]

Micromachined xyz-stages have significant advantages over bulky piezoactuators in terms of size and performance as summarized in a U.S. patent.[8] Examples of this approach can be found in several articles in the literature. Electrostatic microactuators have been developed both as z-scanner[9] and xyz-scanners[10] for SPM applications. Other actuation methods such as piezoelectricity[11] and thermal bimorphs[12] have also been investigated for making micromachined scanners. Micromachined scanners offer high-speed operation and high-precision positioning with multidegrees of freedom.

Larger scale SPM actuator structures with crab-leg flexures similar to that of described by Disseldorp *et al.* have been demonstrated.[13,14] These parallel-plate type electrostatic actuators have a displacement range of up to 40 μm.[13] Another method of using a translational stage for fast SPM scanning is also described in a recently awarded patent.[15] This stage also uses flexural springs and is manufactured using more traditional methods.

The abovementioned literature we believe is necessary to place the research presented in Disseldorp *et al.* in the proper context.

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