# AFM probe structures with integrated interferometric sensing and electrostatic actuation

*F. Levent Degertekin, A. Guclu Onaran, Hamdi Torun, Mujdat Balantekin, Krishna Sarangapani, and Cheng Zhu*

Georgia Institute of Technology
G.W. Woodruff School of Mechanical Engineering
801 Ferst Dr. NW, Atlanta, GA 30332, U.S.A.
E-mail: levent@gatech.edu

In this talk, we summarize our efforts in development of novel AFM probes and actuators based on extended use of micromachining techniques with a focus on applications in liquid media. The first type of device uses a surface micromachined membrane structure as force sensor which is directly actuated using the built-in electrostatic actuator [1]. This enables fast actuation of the probe tip limited only by the membrane dynamics. The motion of the tip is measured with high sensitivity using an integrated optical interferometer. Membrane structures suitable for in-liquid operation are fabricated on transparent substrates made of quartz or glass. A reflective metal grating is formed on the surface which also serves as one of the actuator electrodes. The membrane is made of dielectric layers, a silicon nitride - silicon oxide stack, or a polymer such as parylene over a sealed gap. The top metal actuator electrode – optical reflector layer is buried in this dielectric layer for electrical isolation in conductive liquids such as buffer solutions. To illustrate application of these probes in single molecule mechanics experiments, they were used to measure unbinding forces between L-selectin reconstituted in a polymer-cushioned lipid bilayer on the membrane and an antibody adsorbed on an AFM cantilever. Piconewton range forces between single pairs of interacting molecules were measured from the cantilever bending while using the membrane as an actuator. The integrated diffraction-based optical interferometer of the probe was demonstrated to have <10 fm/√Hz noise floor for frequencies as low as 3 Hz with a differential readout scheme. With softer membranes, this low noise level would be suitable for direct force measurements without the need for a cantilever. Furthermore, the probe membranes were shown to have 0.5 μm actuation range, with a flat response up to 100 kHz enabling measurements at high speeds [2]. We also describe a second type of device, the acoustic radiation force (ARP) actuator, for fast imaging in liquids. The ARP actuator uses focused acoustic waves at RF frequency range (100-300MHz) to induce localized forces on AFM cantilevers in liquids. The actuator has an actuation bandwidth in excess of 1MHz and it can be used with any type of AFM cantilever without a need for any magnetic or piezoelectric film. ARP actuator has been integrated to a commercial AFM system and fast tapping mode imaging without a Z-piezo has been demonstrated. Furthermore, single molecule force spectroscopy experiments were conducted using the same system [3].

**1.** A.G. Onaran, M. Balantekin, W. Lee, W.L. Hughes, B.A. Buchine, R.O. Guldiken, Z. Parlak, C.F. Quate and F.L. Degertekin, "A new atomic force microscope probe with force sensing integrated readout and active tip," *Review of Scientific Instruments*, **77**, 023501 (7 pages), 2006.
**2.** H. Torun, J. Sutanto, K.K. Sarangapani, P. Joseph, F.L. Degertekin and C. Zhu, "Micromachined membrane-based active probe for biomolecular mechanics measurement," submitted to *Nanotechnology*, 2006.
**3.** A.G. Onaran and F.L. Degertekin, "A fluid cell with integrated acoustic radiation pressure actuator for atomic force microscopy", *Review of Scientific Instruments*, **76**, 103703, (6 pages) 2005.