Radio-Frequency Cantilevers for Scanning Probe Microscopy

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Abstract:

We are fabricating radio-frequency silicon nitride cantilevers for the use in scanning probe microscopy. These cantilevers will be used to study dielectric fluctuations above thin polymers films and charging behavior in organic field-effect transistors. Further, we have fabricated doubly-clamped cantilevers of similar dimension and constituency and employed a magnetomotive scheme to measure their frequencies (≈ 5 MHz) and quality factors (≈ 70,000).

Summary:

Scanning probe microscopy is a valuable technique for studying properties of thin organic films, such as charging and charge trapping in organic field-effect transistors (OFETs) [1] or dielectric fluctuations above thin polymers surfaces [2]. The cantilevers used in such measurements typically have frequencies of no more than a couple hundred kilohertz. Unfortunately, many phenomena such as charge trapping in OFETs occur on a sub-microsecond timescale; too short to be imaged in real-time by the cantilevers conventionally used in scanning probe microscopy. Switching to radio-frequency (RF) cantilevers would enable us to study these processes. To our knowledge, this would be the first time anyone has ever performed a scanning probe experiment using RF cantilevers. Further, successfully realizing an RF scanning probe experiment opens up the exiting possibility of employing RF cantilevers in magnetic resonance force microscopy (MRFM) [3]. The new set of cantilevers could potentially revolutionize the field of MRFM.

Singly-clamped cantilevers with adjacent electrodes are fabricated from a <100> silicon wafer with 600 nm of silicon dioxide grown by thermal oxidation and 250 nm of silicon nitride deposited by low-pressure chemical vapor deposition. Electron beam lithography is used to pattern the cantilevers and the adjacent electrodes (Figure 1). The purpose of the electrodes is to capacitively drive and detect the resonator [4]. Using aluminum as an etch mask, the nitride cantilevers are defined via reactive ion etching. Optical lithography is then used to write the electrical interconnects to the off-chip measuring apparatus. Finally, the backside of the wafer is patterned with photo resist and etched all the way to the oxide layer on the front side of the wafer using a Bosh etch process on the Unaxis 770. Finally, the cantilevers are released in buffered hydrofluoric acid. Images of the resulting devices are shown in Figures 2 and 3.

Figure 1
We have also fabricated doubly-clamped cantilevers using a similar procedure. These cantilevers were characterized by a magnetomotive detection scheme [5]. The intrinsic quality factor was found by conducting measurements in a range of magnetic fields (0.5T-6T) and extrapolating to the zero-field limit. From these measurements we determined the frequency and zero-field quality factor to be 5.5 MHz and 80'000, respectively. Though we have not yet been able to characterize our singly-clamped resonators, we expect them to have quality factors and resonance frequencies of similar magnitude.

References:


