MECHANICAL RESONANCEOF INDIVIDUAL NANOSTRUCTURES

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ABSTRACT

In this thesis the non-contact mode atomic force microscopy (NCM AFM) was used to measure very high frequency (VHF) mechanical resonance (MR) of individual nanostructures. The effect of coupling between the probe and sample on the measured resonant frequency, for both contact mode AFM (CM AFM) and NCM AFM, was analytically evaluated and showed the NCM AFM as superior due to the gentle interaction.

The NCM AFM was experimentally validated by first demonstrating a high frequency resonant measurement of a piezo. An electrically driven piezo (with a 1 cm^2 Si piece glued on top) was found to have a clear MR of ~11.8 MHz using the NCM AFM resonant technique. We also showed that the NCM AFM technique was able to detect a 41 MHz vibration. Comparing the optically measured MR of a series of cantilevers with NCM AFM measured MR showed virtually no shift of the resonant frequency of the sample cantilevers. In addition, the sample cantilever was driven at its first harmonic frequency while the vertical displacement along its length was measured and its length dependence matched the expected 1st order mode shape.

After having had experimentally validated the NCM AFM technique we went on to measure the VHF (>30 MHz) MR of individual rods and springs. These nanostructures were grown using a newly built oblique angle ebeam deposition (OAED) system.

The MR of individual rods showed resonant peaks ranging from ~30 MHz to ~160 MHz. The MR of the rods were further confirmed by observing scanning electron microscopy (SEM) image blurring (rod vibration). Nanometer scale spring samples were grown in the OAED system. The MR of the spring samples was measured and found to lie between ~30 and ~300 MHz.

The measured MR of both rod and spring samples were compared with

theoretical values. The comparison took into account variations in sample geometry and had good agreement. This thesis work demonstrates for the first time the validity of the using the NCM AFM technique to measure the mechanical resonance frequency of individual nanostructures.