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Vibration analysis of different AFM cantilever with a piezoelectric layer in the vicinity of rough surfaces

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Abstract

Atomic force microscope (AFM) is widely used in a nanolithography and MEMS as one of the most powerful tools for surface topography in Nano scale. There has recently been a growing interest in piezoelectric layers as sensors in AFM cantilevers. In this paper, the dynamic behaviors of rectangular, dagger and V-shape AFM cantilevers in the transverse direction were examined in the air. Each cantilever consists of three regions; the first region is made of four layers including the silicon layer, the first electrode, the piezoelectric layer and the second electrode and the second and third regions both consist of a silicone layer. In order to enhance computation accuracy in obtaining the partial differential equation (PDE) corresponding to cantilever motion, modified couple stress (MCS) and Hamilton theories were used. Subsequently, the PDE was converted into ordinary differential equation (ODE) using the numerical generalized differential quadrature method (GDQM). In order to validate the analysis method, the findings were compared with experimental and FEM results. The effect of applied forces on the cantilever in this setting including Van der Waals, capillary, and contact forces on the oscillating domain of the cantilever was studied. The time response of the cantilever tip was obtained with respect to different distances between the cantilever and the surface. Different roughness models are introduced and the effect of each of them on the sample surface topography at the tapping and none contact mode was investigated. The results illustrated that in both the non-contact and tapping mode, the cantilever with its second natural frequency provides a better response than one with the first natural frequency. Among the three investigated cantilevers, the best topography was associated with the rectangular cantilever.

Keywords: AFM, Piezoelectric, Modified Couple Stress, Time Response, Surface Topography, Roughness

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