The flexural vibration of V shaped atomic force microscope cantilevers by using the Timoshenko beam theory

Nima Refahati, Ali Sadeghi

Department of Mechanical Engineering, Damavand Branch, Islamic Azad University, Damavand, Tehran, Iran
refahati@damavandiau.ac.ir

The resonant frequency of flexural vibration for a V shaped atomic force microscope (AFM) cantilever has been investigated using the Timoshenko beam theory. Generally, three Different regions are considered for V shaped cantilevers, one region with constant cross section and height and two double tapered regions. In this paper, the effects of the contact position, contact stiffness, the height of the tip, thickness of the beam, the height and breadth taper ratios of cantilever , the angle between the cantilever and the sample surface and width ratio based on Timoshenko beam theory on the non-dimensional frequency and sensitivity to the contact stiffness have been studied. The differential quadrature method (DQM) is applied to solve the nonlinear differential equations of motion. The results show that the resonant frequency decreases when Timoshenko beam parameter or cantilever thickness increases and high order modes are more sensitive to it. The first frequency is sensitive only in the lower range of contact stiffness, but the high order frequencies are sensitive to the contact stiffness in a larger range. It is possible to increase the range of sensitivity to the contact stiffness by increasing the width ratio for the first mode. All vibrational modes are sensitive to the angle $\alpha$ between the cantilever and sample surface and by increasing angle, the non-dimensional frequency decreases. By increasing the height $H$, for a limited range of contact stiffness the sensitivity to the contact stiffness increases. By increasing both height and breadth taper ratios the resonant frequency increases. The resonant frequency is sensitive to the width ratio and by increasing this ratio, the resonant frequency decreases, but critical contact stiffness increases and finally the variations of the height and breadth taper ratios and width ratio are affected.
References

[8] Song Y, Bhushan B 2006 Simulation of dynamic modes of atomic force microscopy using a 3D finite element model ultramicroscopy; 106; 847-73