

FEM simulations on the effect of the thermal-induced surface stress on ultrathin resonators

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Nanoelectromechanical (NEMS) resonators have been developed for use as ultrasensitive sensors including mass sensors, chemical sensors, force sensors and photothermal transducers. A strong motivation for scaling down resonators is to increase their sensitivity and reduce the effect of thermomechanical noise, thereby improving the resolution of resonant sensors and also enhancing their response time. This development has increased the sensitivity limit up to the extent that researchers can now visualize the counting of molecules. With the ability of high throughput analysis of analytes and ultrasensitive detection, NEMS resonators potentially hold tremendous promise for the next generation of miniaturized and highly sensitive sensors.

However, scaling the dimensions of a resonator down to the NEMS range, the only action of cantilever detecting cans highly perturb the system itself.

Optical detection is a well known method commonly used in detecting resonance frequencies in atomic force microscopes and in mass/force sensing. The method focuses a laser spot on the surface of cantilevers to be measured, offering the possibility to inspect all the dynamical properties of the beam.

In this work it is shown that thermal laser-induced effects can cause a significant amount of frequency shift in the resonator. FEM simulations reveal the importance of the effect of the thermal-induced surface stress on the frequency resonance shift. Thermal laser-induced stresses strongly modify the dynamical properties of ultrathin cantilevers, affecting in a drastic way their measurement accuracy. Our theoretical work suggests that laser detection effects have to be seriously take into account when resonator dimensions are strongly reduced.

References

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Figures

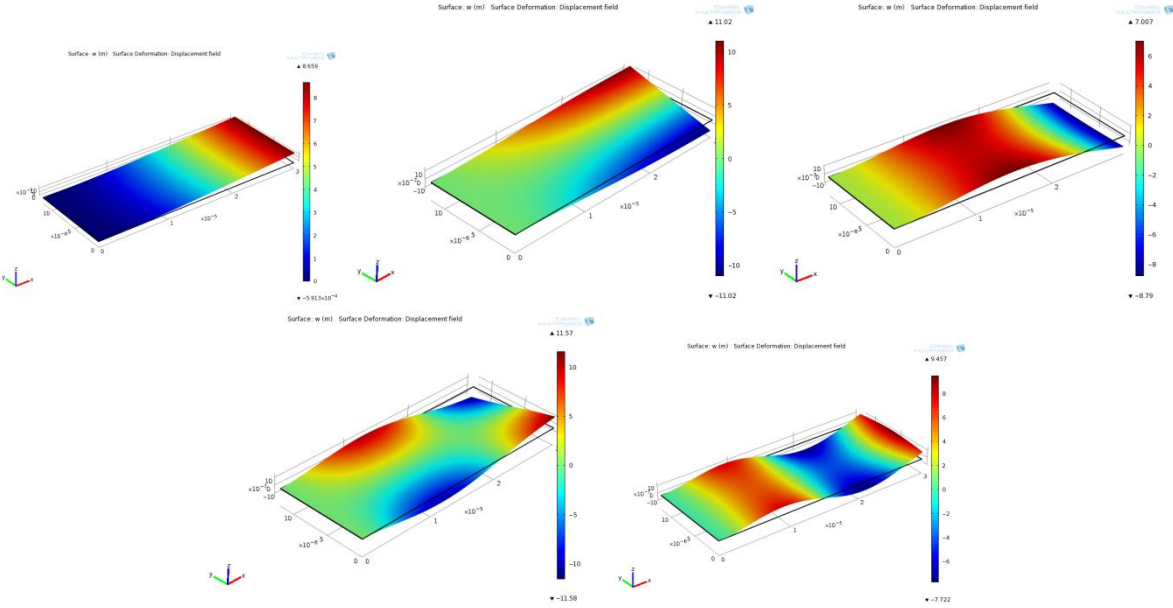


Fig.1 FEM simulation of the first five resonance mode of an ultrathin cantilever (50 nm) subjected to a no-linear deformation produced by thermal-induced surface stresses.

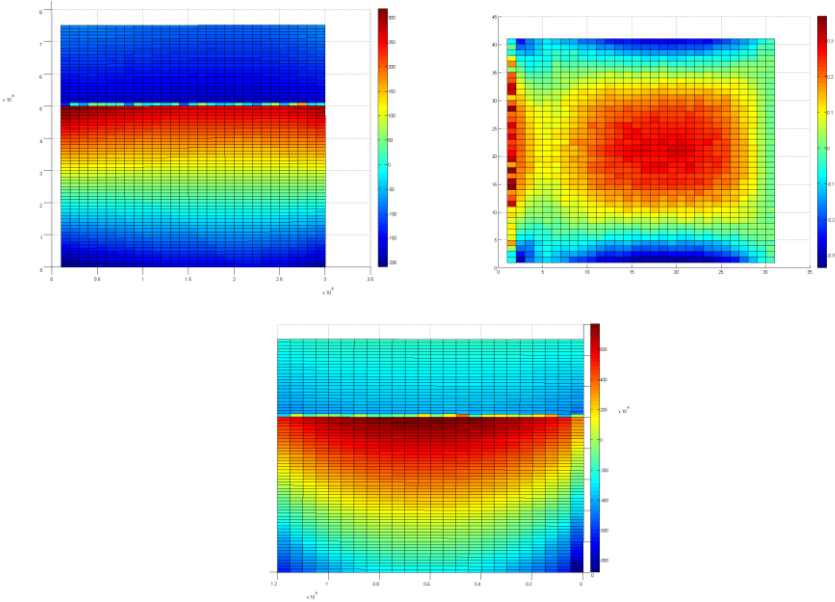


Fig.2 FEM simulations of the thermal-induced axial stress σ_x integrated along the X, Y, Z axis.