Resonant Frequencies Of A Nanoscale Fractal Resonator

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Abstract

A top-down nanosize mechanical resonator has been fabricated with a shape of a fractal. The self-similar structure consists of star-polygons and it is suspended over a 10 µm trench and has width of 12 µm. Its thickness of 0.040 µm is defined by the fabrication process and prescribes Young's modulus of 76 GPa (fit by COMSOL Multiphysics®) which is significantly lower than the value of the bulk material. The mechanical resonator is electrostatically excited and the resulted multiple resonant peaks spread between 2 MHz and 24 MHz. The COMSOL Multiphysics® MEMS Module has been used to vary material properties and residual stress in order to fit the eigenfrequencies of the model with the resonance peaks detected experimentally. Moreover, by using COMSOL Multiphysics®we show how the symmetry of the device and the residual stress affect the order at which the vibration modes appear in the spectrum. Furthermore, by using our model, the possibility for an electrical read out of the device was successfully tested. The experimental measurements and simulations proved that the device can resonate at many different excitation frequencies allowing multiple operational bands.

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Figures used in the abstract

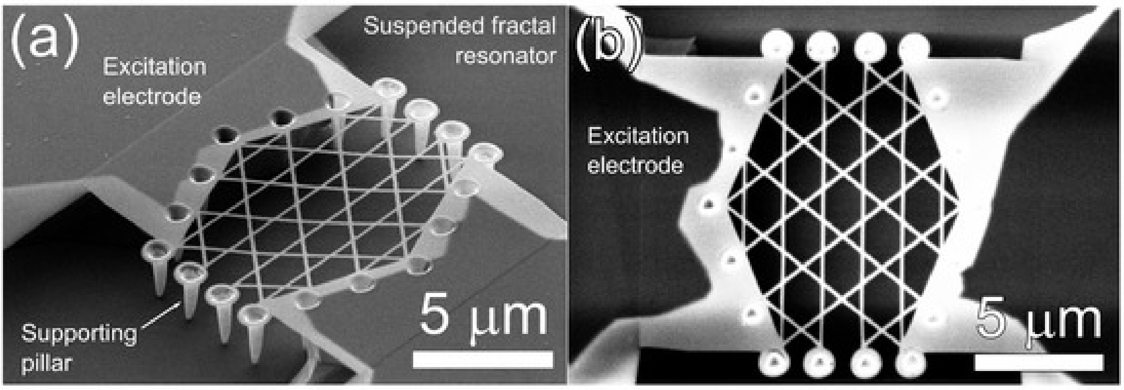

Figure 1 : SEM images of the fractal nano structure: (a) 45 degree tilted SEM image of the suspended fractal resonator. (b) Top-view SEM image of the suspended structure.

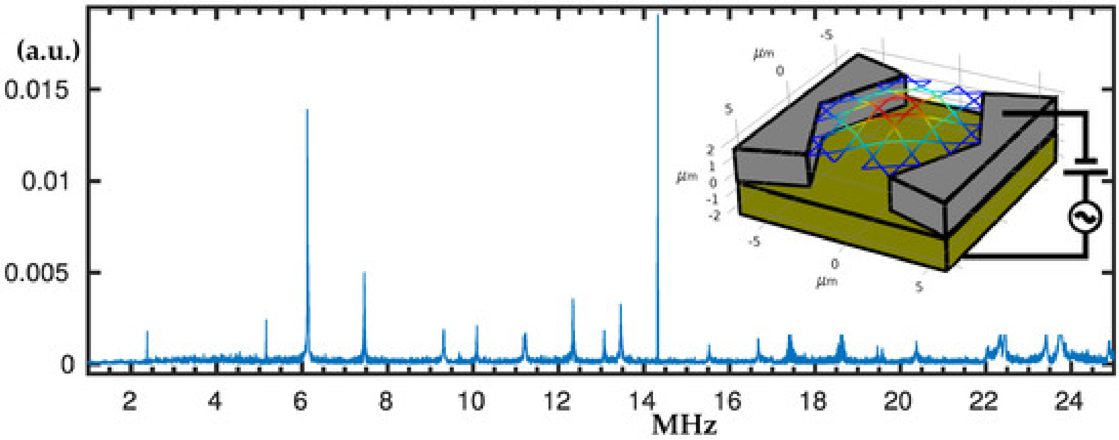

Figure 2 : Experimentally measured frequency response spectrum produced by using electrostatic actuation and optical interferometric detection.

Fractal resonator		
Compression		4 nm
Maximum Bending Displacement		82 nm
Temperature		296 K
Mode	Experimental	Numerical
even-(1,1)	2.4 MHz	2.783 MHz
even-(0,1)	5.15 MHz	5.107 MHz
odd-(1,1)	6.1 MHz	6.06 MHz
odd-(2,1)	7.15 MHz	8.043 MHz
even-(2,1)	9.22 MHz	8.5151 MHz

Figure 3 : Table of the first five resonant modes and a comparison between the experimental and COMSOL simulated resonant frequencies.