Resonant pull-in condition of microbeam with electrostatic force actuation using couple stress theory

Gyana Ranjan Saw[a,*], Goutam Chakraborthy[b]

[a]*Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, 721302, India*
[b]*Professor, Department of Mechanical Engineering, Indian Institute of Technology Kharagpur, 721302, India*

Abstract

Miniaturized structures such as microbeam, microwires, microplates, and nanotubes, microshells, etc have been widely explored in microsystem devices. Microbeams are critical components of many consumer products, as well as the upcoming industrial revolutions. Microbeams have widely used in sensors and actuator due to their potential sensitivity and high frequency in micro electro mechanical systems(MEMS). MEMS are usually a elastic conductive microbeam with two ends fixed, suspended on a rigid plate on fixed surface, filled with dielectric medium. The external damping and electrostatic force are evolved respectively due to fluid medium and potential voltage between them. The modified couple stress theory is one of the non classical continuum approach is invoked, consequence of the material has void, electric dipole etc in micro/nano scale level. Collecting all the energies term, the governing partial differential equation(PDE) is derived from Hamiltonian principle. The PDE is solved by Galerkin method, which is one of the reduced order model(ROM) of closed form solutions. The homogeneous part is solved by using an eigenvalue based problem to calculate a microbeam's mode shape function. When the non-conservative force like electrostatic is exceeded the elastic restoring force by increasing the voltage. Beyond a certain voltage limit the beam is to deform, called pull-in voltage. The resonant pull-in and other parameters are affected to the beam. The microbeam models are verified by COMSOL Multi physics 5.6 FEM and results are compared with analytical method.

Keywords: MEMS, pull-in, Couple stress, Electrostatic force, Galerkin method, Micro beam.

*Corresponding author
Email addresses: sgyana87@gmail.com (Gyana Ranjan Saw), goutam@mech.iitkgp.ac.in (Goutam Chakraborthy)