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Dynamic stability of electrostatic torsional actuators with van der Waals effect

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Abstract

The influence of van der Waals (vdW) force on the stability of electrostatic torsional nano-electro-mechanical systems (NEMS) actuators is analyzed in the paper. The dependence of the critical tilting angle and voltage is investigated on the sizes of structure with the consideration of vdW effects. The pull-in phenomenon without the electrostatic torque is studied, and a critical pull-in gap is derived. A dimensionless equation of motion is presented, and the qualitative analysis of it shows that the equilibrium points of the corresponding autonomous system include center points, stable focus points, and unstable saddle points. The Hopf bifurcation points and fork bifurcation points also exist in the system. The phase portraits connecting these equilibrium points exhibit periodic orbits, heteroclinic orbits, as well as homoclinic orbits.

Keywords: Electrostatic torsional actuator; van der Waals force; Pull-in; Stability; Bifurcation; Periodic orbit; Heteroclinic orbit; Homoclinic orbit

1. Introduction

The van der Waals (vdW) interaction between two macroscopic bodies (spheres, film, plates etc.) has been widely investigated for nearly half a century (Lifshitz, 1956; Høye and Brevik, 1998; Boström and Sernelius, 2001; Kirsch, 2003). It became more emerging in recent years because of its profound theoretical background in the fields of atomic force microscopy (AFM), nano/micro-electro-mechanical-systems (NEMS/MEMS) devices, etc. The vdW force dominates the interaction between the probe of AFM and

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