Ruzziconi, Laura; **Younis, Mohammad I.**; **Lenci, Stefano**

An electrically actuated imperfect microbeam: dynamical integrity for interpreting and predicting the device response. (English) Zbl 1293.74271

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Summary: In this study we deal with a microelectromechanical system (MEMS) and develop a dynamical integrity analysis to interpret and predict the experimental response. The device consists of a clamped-clamped polysilicon microbeam, which is electrostatically and electrodynamically actuated. It has non-negligible imperfections, which are a typical consequence of the microfabrication process. A single-mode reduced-order model is derived and extensive numerical simulations are performed in a neighborhood of the first symmetric natural frequency, via frequency response diagrams and behavior chart. The typical softening behavior is observed and the overall scenario is explored, when both the frequency and the electrodynamic voltage are varied. We show that simulations based on direct numerical integration of the equation of motion in time yield satisfactory agreement with the experimental data. Nevertheless, these theoretical predictions are not completely fulfilled in some aspects. In particular, the range of existence of each attractor is smaller in practice than in the simulations. This is because these theoretical curves represent the ideal limit case where disturbances are absent, which never occurs under realistic conditions. A reliable prediction of the actual (and not only theoretical) range of existence of each attractor is essential in applications. To overcome this discrepancy and extend the results to the practical case where disturbances exist, a dynamical integrity analysis is developed. After introducing dynamical integrity concepts, integrity profiles and integrity charts are drawn. They are able to describe if each attractor is robust enough to tolerate the disturbances. Moreover, they detect the parameter range where each branch can be reliably observed in practice and where, instead, becomes vulnerable, i.e. they provide valuable information to operate the device in safe conditions according to the desired outcome and depending on the expected disturbances.

MSC:

74K10 Rods (beams, columns, shafts, arches, rings, etc.)
74F15 Electromagnetic effects in solid mechanics
74H45 Vibrations in dynamical problems in solid mechanics
74M25 Micromechanics of solids

Keywords:

microelectromechanical systems; multistability; nonlinear dynamics; dynamical integrity

Software:

Dynamics

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