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Nonlinear Dynamic Behavior Analysis of Micro Electrostatic Actuator based on a Continuous Model Under Electrostatic Loading

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Abstract

Analyzing the dynamic behavior of microelectrostatic devices is problematic due to the complexity of the interactions between the electrostatic coupling effect, the fringing field effect, the residual stress, the tensile stress, and the nonlinear electrostatic force. In this study, this problem is resolved by modeling the electrostatic system using a continuous model and solving the resulting governing equation of motion using a hybrid scheme comprising the differential transformation method and the finite difference method. The feasibility of the proposed approach is demonstrated by modeling the dynamic responses of two fixed-fixed microbeams when actuated by a dc voltage. It is shown that the numerical results for the pull-in voltage deviate by no more than 1.74% from those presented in the literature. The hybrid scheme is then applied to examine the nonlinear behavior of one clamped microbeam actuated by a combined dc/ac scheme. The beam displacement is analyzed as a function of both the magnitude and the frequency of the ac voltage. Finally, the actuating conditions, which ensure the stability of the microbeam, are identified by reference to phase portraits and Poincaŕ maps. Overall, the results presented in this study show that the hybrid differential transformation and finite difference method provides a suitable means of analyzing a wide variety of common electrostatically actuated microstructures.

Key words: Differential transformation;Finite difference method;
Hybrid method;MEMS;Microelectrostatic device