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Nonlinear Structural Behavior of Micro- and Nano-Actuators Using the Galerkin Discretization Technique

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Abstract : In this paper, the influence of van der Waals, as well as electrostatic forces on the structural behavior of MEMS and NEMS actuators, has been investigated using of a Euler-Bernoulli beam continuous model. In the proposed nonlinear model, the electrostatic fringing-fields and the mid-plane stretching (geometric nonlinearity) effects have been considered. The nonlinear integro-differential equation governing the static structural behavior of the actuator has been derived. An original Galerkin-based reduced-order model has been developed to avoid problems arising from the nonlinearities in the differential equation. The obtained reduced-order model equations have been solved numerically using the Newton-Raphson method. The basic design parameters such as the pull-in parameters (voltage and deflection at pull-in), as well as the detachment length due to the van der Waals force of some investigated micro- and nano-actuators have been calculated. The obtained numerical results have been compared with some other existing methods (finite-elements method and finite-difference method) and the comparison showed good agreement among all assumed numerical techniques.

Keywords : MEMS, NEMS, fringing-fields, mid-plane stretching, Galerkin
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