Shape Optimization of Electrostatically Driven Microcantilevers using Simulated Annealing to Enhance Static Travel Range

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Abstract

The objective of this paper is to present a systematic development of the generic shape optimization of electrostatically actuated microcantilever beams for extending their static travel range. Electrostatic actuators are widely used micro electro mechanical system (MEMS) devices because of low power density and ease of fabrication. However, their useful travel range is often restricted by a phenomenon known as pull-in instability. The Rayleigh- Ritz energy method is used for computation of pull-in displacement and pull-in voltage which includes electrostatic potential and fringing field effect. Keeping the volume constant, the parameters which can be varied are width and thickness of the nonprismatic microcantilever beam. Appropriate width function and linear thickness functions are employed along the length of the beam to achieve enhanced travel range. Parameters used for varying the thickness and width functions are optimized using simulated annealing with pattern search method towards the end to refine the results. Appropriate penalties are imposed on the violation of volume, width, thickness and area constraints. Nine test cases are considered for demonstration of the said optimization method. The results indicate that around 26% increase in the travel range of a nonprismatic beam can be achieved after optimization compared to that in a prismatic beam having the same volume. It is also found that results show an improvement in the pull-in displacement of around 5% compared to that of a variable width actuator. In the area of MEMS simulated annealing with the pattern search method at the end has not been used much. This paper addresses the utility and flexibility of simulated annealing with pattern search method at the end to find optimal design of structural elements under electrostatic loading.

Keywords *Optimization, Simulated annealing, Electrostatic actuator, Pull-in instability, Variable geometry, Microcantilever beam*