Design and Fabrication of Bistable MEMS Switch using BEOL Compatible Process and Tuning of Residual Stress

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July 26, 2023

Abstract

A Laterally driven Cu Electroplated, initially curved bi-stable MEMS microbeam is designed and fabricated with optimized electroplating parameters which can be used as a switch. The main challenge of the design is to control stress and reduce actuation voltage. This will be achieved by utilizing a curved fixed-fixed beam design. The bistable mechanism ensures that the device does not have static power consumption. Structures can be lithographically defined By using lateral structure instead of the normal out-of-plane structure. Further, lateral switches lend themselves to much more complex arrays of switches. The beam is fabricated using a UV-LIGA process, using electroplated copper as the structural material and photoresist as the sacrificial layer. Recent advances in damascene electroplating and TSV technology have opened the doors for nanostructures that can be made by electroplating alone.

A key challenge here is controlling the film stress during deposition and in use. To achieve these, this work explores the effect of plating parameters to tune residual stress in the microstructure fabricated using UV-LIGA process. The electroplating parameters are optimized by varying the reverse plating current period and plating bath temperature to see the variation in the stress. Furthermore, the measured stress for different electroplating parameters is compared to see the effect of parameters on deposited film. It is discovered that these parameters significantly influenced the microstructure of Cu films and residual stress induced in the film. Stress developed during fabrication is measured by micro-strain gauge test structures rather than XRD, wafer curvature method, PL-Raman as this is the most accurate method from a device point of view. The fabricated initially curved bistable structure is actuated by Lorentz force using NdFeb Magnet, which gives an actuation voltage of less than 5 volts. An electrostatically actuated hollow beam has also been designed and simulated. The switching voltage and latching mechanism of curved shape latched hollow beam subjected to electrostatic force has been investigated using a reduced order model have been derived and validated against a FEM model. A 4X reduction in switching voltage is obtained from an electrostatically actuated solid bistable MEMS beam. The problems encountered during fabrication are also discussed.