ABSTRACT

Micro Electro Mechanical Systems (MEMS) is a technology which is used to fabricate the components in miniature form in all science and engineering fields. Cantilever is a simple device which is comparatively easy to design and fabricate and it also finds wide application as sensors and actuators in different areas of MEMS technology. The literature review indicates the necessity of designing cantilever-based MEMS devices with improved performance. Therefore, this thesis mainly concentrates on the design, analytical modeling and fabrication of cantilever-based MEMS devices with improved performance.

The pull-in voltage models with the fringe fields are available in literature, but only considered for limited range of dimensions. So, firstly, the thesis takes into consideration of development of pull-in voltage models for cantilever beam with fringe fields, for wider range of dimensions. The pull-in voltage computed from these closed form models are compared with the FEM (Finite Element Method) simulation results and experimental results of the fabricated device. The results are validated and it is observed that a particular pull-in voltage model is better suited for only a particular range of dimension.

The second and third part of this thesis focuses on the improvement of displacement in comb-drive which is the most widely used microactuator. Analytical modeling of single finger with fringe field effect is done. For the improvement of performance of this simple cantilever based comb drive, non-rectangular finger shapes have been considered. All the suggested finger shapes have been designed, modeled, simulated and experimentally tested and validated for the improvement in
displacement. Further, the derived pull-in voltage models are used to determine the safe operating voltage range for applying voltage excitation on the designed microgripper.

The electro thermal actuators are also much appreciated in the field of MEMS actuators. Therefore, the fourth part of the thesis focuses on the analytical modeling and the performance improvement of the cantilever based Electro Thermal Compliant actuator (ETC). The design and analytical model of a gold-coated ETC actuator is developed and its FEM model is simulated. Using the SOIMUMP technology the thermal actuator is fabricated. It has been tested and validated for its increased displacement, as against the non-coated device. The shape of the actuator is then modified resulting in further improvement of its displacement.

MEMS devices based on cantilevers utilize numerous transducing mechanisms not only for actuation but also for sensing. Therefore the last part of the thesis focuses on the cantilever based bio-sensor. The bio-molecule of interest in this work is low density lipoproteins (LDL). LDL in human blood is said to be the major cause for the formation of atherosclerosis plaque in coronary artery which may lead to heart attack. In this work an investigation is done with the cantilever structure to sense the number of LDL molecules in blood. Simulation study is done to investigate the performance of a Wheatstone bridge based piezoresistive cantilever. A tapered cantilever beam arrangement is also proposed to enhance the displacement of the sensor.

Therefore, the performance of the chosen cantilever based actuators and sensors are improved with the suggested designs and analytical models and the results are validated.