Analysis & Design Optimization of Laterally Driven PolySilicon Electro-thermal Microgripper for Micro-objects Manipulation

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Abstract

Micro-grippers find applications in micro-robotics, microsurgery, micro-fluidics, micro-relays, assembling and miniature medical instrumentation. Actuation principle involved may be electrothermal, electrostatic, piezoelectric, shape memory and electromagnetic. It has been found that thermal actuation provides greater displacement at low voltages when compared to other mechanisms. A 3-D electrothermally driven micro-gripper has been designed using COMSOL Multiphysics. Micro-gripper is comprised of two microactuators (hot-and-cold-arm actuator) which operates on the basis of joule heating and thermal expansion. Despite of the recent progress, most available micro-grippers are still suffering of high voltage requirement. The gripper presented here is geometrically optimized to explore the effect of dimension variation on the performance. The total dimensions of the structure are within 705µm×235µm area, including contact pads. Length and Width of hot beam is 600µm and 10µm respectively whereas length and width of the cold beam is 250µm and 75µm respectively with a common thickness of 5µm.The initial opening between the gripping arms is 15µm. Tip displacement is computed by varying the length of the hot beam and gap between the hot and cold beams. The maximum voltage applied is 3V. When the length of the hot beam is varied from 500µm to 700µm, the displacement increases from 7.36µm to 11.08µm with constant gap of 5µm as shown in figure1 and figure4. When gap between the beams is decreased from 15µm to 5µm, the displacement increases from 6.71µm to 9.22µm with constant hot beam length of 600µm as shown in fig.2 and fig.3.The maximum temperature rise in the structure is 654.30C. It has been concluded that the displacement increases by increasing the length of the hot beam and decreasing the gap between the hot beam and cold beam.

Reference

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Figures used in the abstract

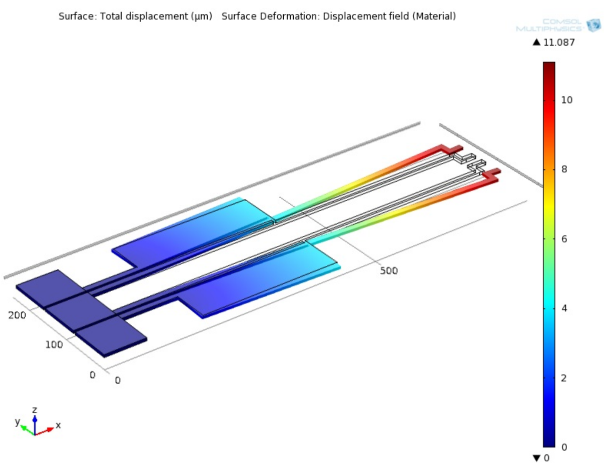

Figure 1: Displacement when hot arm length 700µm.

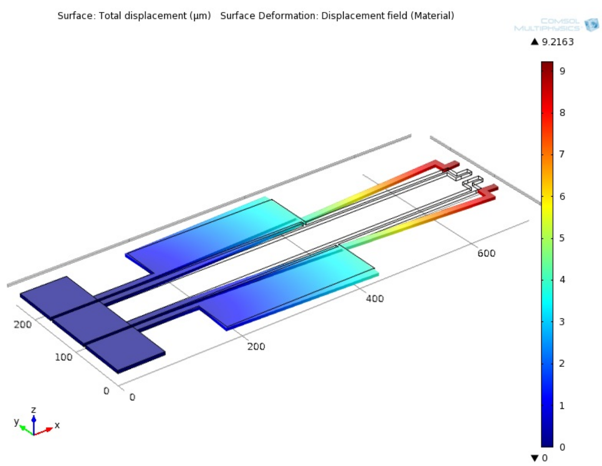

Figure 2: Displacement when gap between beams 5µm.

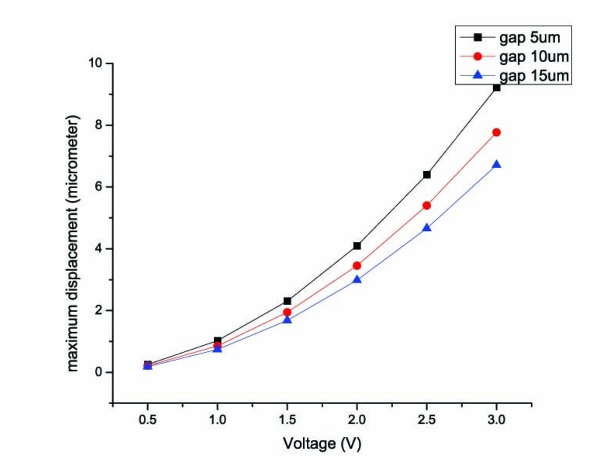

Figure 3: Displacement with variable gaps between the beams.

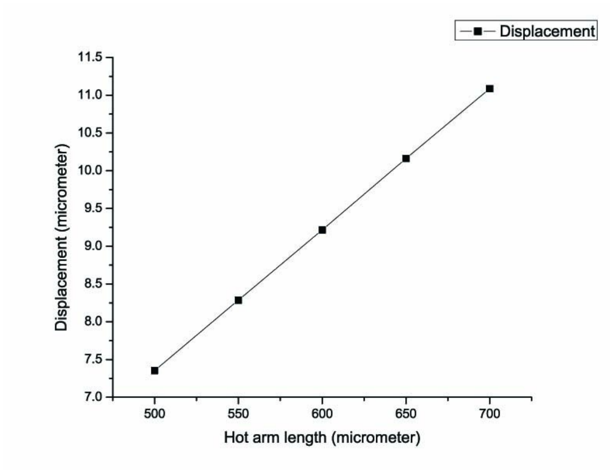

Figure 4: Displacement with variable hot arm length.