Design and Analysis of MEMS Micro Mirror Using Electro Thermal Actuators

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Abstract

Micro Mirror is a versatile device which has been gaining popularity and also the importance of MEMS techniques to develop such devices. These mirrors find applications in fields such as optical switching, display and in medical fields for non-invasive imaging. A thermally actuated mirror moves in either vertical or horizontal directions for the given orientation. The ends of thermal actuators are attached to the edges of the mirror. Thus when voltage is applied to the thermal actuator, the actuation in the actuator makes the attached mirror to tilt. In this paper, we discuss about the actuation of mirror using two electro thermal actuators with the emphasis on reducing the complexity for smaller applications and the design of a mirror which can be used for beam steering application in optical systems. A mirror design capable of the above mentioned movement is simulated with COMSOL Multiphysics. The use of COMSOL Multiphysics is due to the flexibility in this particular CAD tool to prepare the mirror structure and the thermal actuators which need to be analyzed in the Joule heating module to obtain the results. These results are required from various parameters such as temperature variation, displacement with respect to change in temperature and effects of temperature on semiconductor material. Analysis of the device will be carried out where the displacement of the device for a wide voltage range will be measured and these results will be analyzed. COMSOL Multiphysics provides an environment for analysis as required for this work, where the displacement and temperature variation at various points of the structure have to be measured. Variations in this would help calculating the change in displacement when the temperature is changed. The simulation also points out the places where the temperature is high and show color gradation in the figure with respect to that. This device has a displacement in the x-axis, the y-axis and the z-axis for a voltage range of 0-10V. The temperature ranges from 300K - 1035.3K for the voltages has been observed in the process. This temperature exceeds the melting point of silicon when the voltage crosses 9 volts over which the material may no longer holds to its original form of crystalline structure. There after a combination of voltages over the actuators are set forth and all displacements are being analyzed so that one can arrive at the best result for the voltage for best displacement. The displacement is probed from one end of the mirror surface on the diagonal as mentioned before. More analysis is expected to be performed on the structure to explore the possibilities in reducing the size and increased efficiency at low voltages. This mirror can be a potential device option for beam steering micro mirror and can be made more space efficient for purposes where only one degree of freedom is required for the mirror to operate. This design is focused at the SOI-mumps fabrication process and thereby the thickness of the device layer for a 10 µm process is analyzed in this effort. Thus the above proposed design will reduce the size of the

device as well as provides larger displacement in the mirror.

Figures used in the abstract

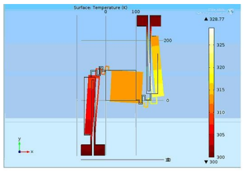

Figure 1: Temperature variation and the mirror displacement in the X direction when dissimilar voltages applied at two ends of actuator.