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Design and Simulation of MEMS Thermal Actuator

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Abstract
This research aims to compare the performance of MEMS electro-thermal actuators with different mechanisms and materials, under similar dimension and boundary conditions. The geometries for the mechanisms mentioned are designed using ANSYS SpaceClaim, whereas the simulation of the actuators is completed through ANSYS Workbench. The actuators are set to have similar dimensions to achieve more accurate results. The input voltage applied varies from 0V to 0.5V. Among electro-thermal actuators made with polysilicon, the bimorph type generates the highest displacement value compared to the hot and cold arm and chevron types. From the material of electro-thermal actuators point-of-view, copper always generates the highest displacement value compared to gold and polysilicon. This is due to the high CTE value of copper, where higher CTE leads to higher displacement. Copper also has the highest thermal conductivity and lowest electrical resistivity among materials implemented. Overall, considering both mechanisms and materials, copper-based Hot and Cold Arm electro-thermal actuators has shown the best performance in electro-thermal actuation, by resulting an increment of 64.08% in total displacement, which is approximately 16.019μ m from its initial length of 25μm. Among all the devices simulated, polysilicon-based Chevron-type actuators generates the least total displacement with a maximum value of 0.60863 nm, which equivalent to an increment of 0.0243 x10^-3% from its initial length. In short, electro-thermal actuators with single material actuates more than devices with bi-materials. Future work includes fabricating the electro-thermal actuators to compare its' performance with this simulated result. © 2024 IEEE.

Author Keywords
displacement; MEMS; thermal actuator

Index Keywords
Integrated circuit design, Kinetics, Microchannels, Polycrystalline materials, Stress intensity factors, Structural analysis, Structural dynamics, Thermal insulating materials; Condition, Design and simulation, Different mechanisms, Displacement, Displacement value, Electro-thermal actuators, Input voltages, MEMS thermal actuators, Performance, Thermal actuator; Polysilicon

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