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ARCHITECTURES FOR INTEGRATION OF CELLULAR MICROSCALE ACTUATOR ARRAYS

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ABSTRACT

The paper proposes the design of several amplification microelectromechanical devices formed of many identical micro-units that are connected in a serial-parallel configuration, each being individually actuated and amplifying its own input motion. The micro-devices realize the border-crossing from the micro- to the meso-scale displacement domain as they combine the micron-level individual inputs into millimeter-range output levels. The base structural unit is a flexure-based compliant device that is capable of transforming the input from a thermo-actuator into an amplified displacement, about a direction perpendicular to the input one. The base unit is designed based on performance criteria such as displacement amplification, input stiffness and output stiffness by utilizing finite element simulation and an algorithm based on closed-form compliance equations of the incorporated flexure hinges. The microelectromechanical amplification device is monitored by means of embedded capacitive displacement sensors, for both the input and output ports. This preliminary analysis will be further utilized to produce and analyze several micro-scale amplification devices.

INTRODUCTION

Microelectromechanical systems (MEMS) have and will continue to have profound changes in the way we engineer control systems. Sensors and computer hardware can now reside in the same piece of silicon so that as a chip "feels" what is going on in its environment it can react to it in software and command actuators to send messages to a user to inform them. This genesis has already led to a host of new products, e.g., MEMS accelerometer based airbag deployment systems, and will without a doubt continue. However, with regard to actuation, the promise of MEMS has fallen short.

Numerous aerodynamic devices have been proposed whereby the claims have been if we coat large aerospace platforms with pimples, these aerodynamic pimples will somehow, "wag the dog." For a number of pragmatic reasons these applications of MEMS have simply not come to fruition. Particle contaminant of the devices, fragility of the thin silicon devices, scale mismatch between device capability and system need, are but a few reasons why some of these approaches haven't worked out.

The promise of MEMS actuators can be paraphrased as something like, "well each actuator may not be very capable but collectively hundreds, thousands or millions of actuators could be used simultaneously to affect the macroscale environment. Proposed in this paper is architecture for microscale actuators to be developed into macroscale devices. The motion of these small mechanisms will be amalgamated into a larger device. As MEMS systems become more complex, demand on MEMS scale actuators may increase and make it necessary to generate large scale forces, e.g., to drive fluids into or out of a laboratory on a chip or move elements fiber optic elements for alignment purposes.

The mechanisms developed here represent mechanical transmissions that can be used to increase the motion generated by transduction. Electrostatics, electromagnetics, piezo-electricity, phase change materials (e.g., shape memory alloys), thermo-mechanical all represent methodologies of transduction, but used directly do not always produce motion at the right throw or force levels. To design an actuator how the energy of transduction is transferred to a load must also be considered. For example, when an electro-magnetic motor to achieve reasonable power density, a small motor is used spins at high velocity and low torques and is how has a gearhead which