DSC-Vol. 62/HTD-Vol. 354, Microelectromechanical Systems (MEMS)
ASME 1997

MEMS FOR FLUIDIC CONTROLS

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Abstract

During the past decade, micromachining technology has become available to fabricate micron- sized mechanical parts. Micromachines have several unique features. First, typical micromachined transducer sizes are on the order of 100 microns, which can be one or more orders of magnitude smaller than traditional sensors and actuators. The drastic reduction in inertia due to these smaller sizes means a substantial increase in the frequency response. Second, the batch processing, which is characteristic of IC fabrication, can be used to make a large number of transducers for distributed sensing and actuation over a wide area. This capability enables us to sense certain flow characteristics in a 2-D domain and to perform control at the proper locations. Potential application areas include the reduction of surface shear stress in a turbulent boundary layer. Third, micromachine manufacturing technology is derived from, though not completely compatible with, IC fabrication so it is possible to integrate the IC with micro transducers to provide logic capability. The integrated microelectronics and micromachines constitute an integrated micro system, which is capable of executing sense-decision-actuation on a monolithic level.

A micro system for shear stress reduction was fabricated on a 1-cm x 1-cm die; 18 micro shear-stress sensors, 3 micro flap actuators, as well as circuits for logic sensor drivers, and actuator drivers are monolithically integrated. The lifetime of the high-speed streaks is short, and a large number of the streaks need to be controlled at the same time. If all of the sensor outputs were to be sent to a central computer and the control command were to be sent from the computer to each actuator, a very high bandwidth signal path and large number of leads would be required. Implementing local and simple signal processing is obviously a necessity for alleviating these problems. Neural networks are a viable approach. A neural-network-based circuit was developed to determine the time and the spatial extent of the high-speed streaks passing the shear-stress-sensor array. The output of the circuit was used for actuation.

This work is supported by research grants from Air Force Office of Scientific Research and DARPA.