# Commercial-Off-The-Shelf Microelectromechanical Systems (MEMS) Flow-Measurement Probes Fabricated And Assembled

As an alternative to conventional tubing instrumentation for measuring airflow, designers and technicians at the NASA Glenn Research Center have been fabricating packaging components and assembling a set of unique probes using commercial-off-the-shelf microelectromechanical systems (MEMS) integrated circuits (computer chips).

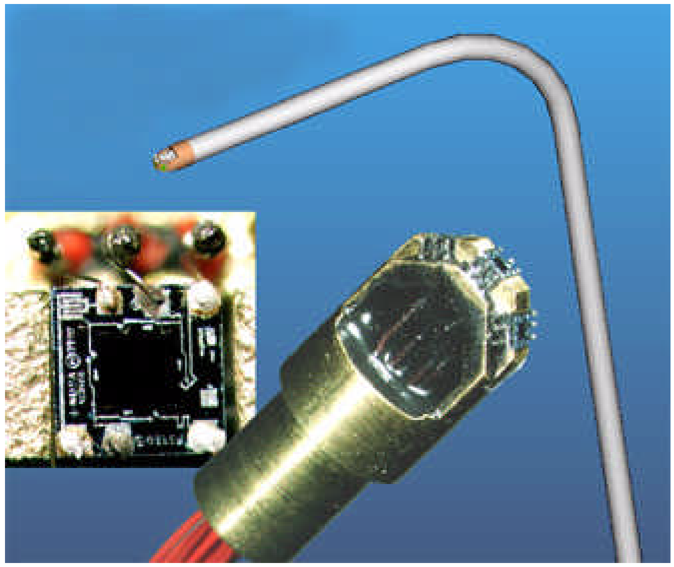
Using MEMS as an alternative has some compelling advantages over standard measurement devices. Sensor technologies have matured through high-production usage in industries such as automotive and aircraft manufacturers. Currently, MEMS are the choice in applications such as tire pressure monitors, altimeters, pneumatic controls, cable leak detectors, and consumer appliances.

Conventional instrumentation uses tubing buried in the model aerodynamic surfaces or wind tunnel walls. The measurements are made when pressure is introduced at the tube opening. The pressure then must travel the tubing for lengths ranging from 20 to hundreds of feet before reaching an electronic signal conditioner. This condition causes a considerable amount of damping and requires measurements to be made only after the test rig has reached steady-state operation. The electronic MEMS pressure sensor is able to take readings continuously under dynamic states in nearly real time.

The use of stainless steel tubing for pressure measurements requires many tubes to be cleaned, cut to length, carefully installed, and delicately deburred and spliced for use. A cluster of a few hundred 1/16-in.- (0.0625-in.-) diameter tubes (not uncommon in research testing facilities) can be several inches in diameter and may weigh enough to require two men to handle. Replacing hard tubing with electronic chips can eliminate much of the bulk. Each sensor would fit on the tip of the 1/16-in. tubing with room to spare.

The P592 piezoresistive silicon pressure sensor (Lucas NovaSensor, Fremont, CA) was chosen for this project because of its cost, availability, and tolerance to extreme ambient conditions. The chip is 1 mm square by 0.6 mm thick (0.039 by 0.023 in.) with 0.12-mm (0.005-in.) wire connection tabs.

Three MEMS chips were used to build the first type of flow-angularity probe. This MEMS probe will be demonstrated as an alternative to a standard tube type "Cobra Probe" now used routinely in wind tunnel and aeronautical hardware applications. The response time and accuracy would allow the probe to be translated on an actuator across a flow field, yielding precision dynamic measurements not possible with conventional instrumentation.



*Commercial-off-the-shelf MEMS flow-measurement probes.*
Composite photograph of the silicon sensor die (chip), an enlargement of a sensor mounted in a probe tip, and an example of a probe formed in an L-shape for insertion into a device under test

The low profile, the minimal power requirement, the rugged construction, and the moderate cost all contribute to making MEMS sensors the enticing choice instrument in future research measurement needs.

The MEMS probe efforts are a continuation of work initiated by Brian Willis, without whose foresight and efforts this project would never have been realized. This task was funded through cooperation with the NASA Electronic Parts and Packaging (NEPP) program at the Jet Propulsion Laboratory.

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