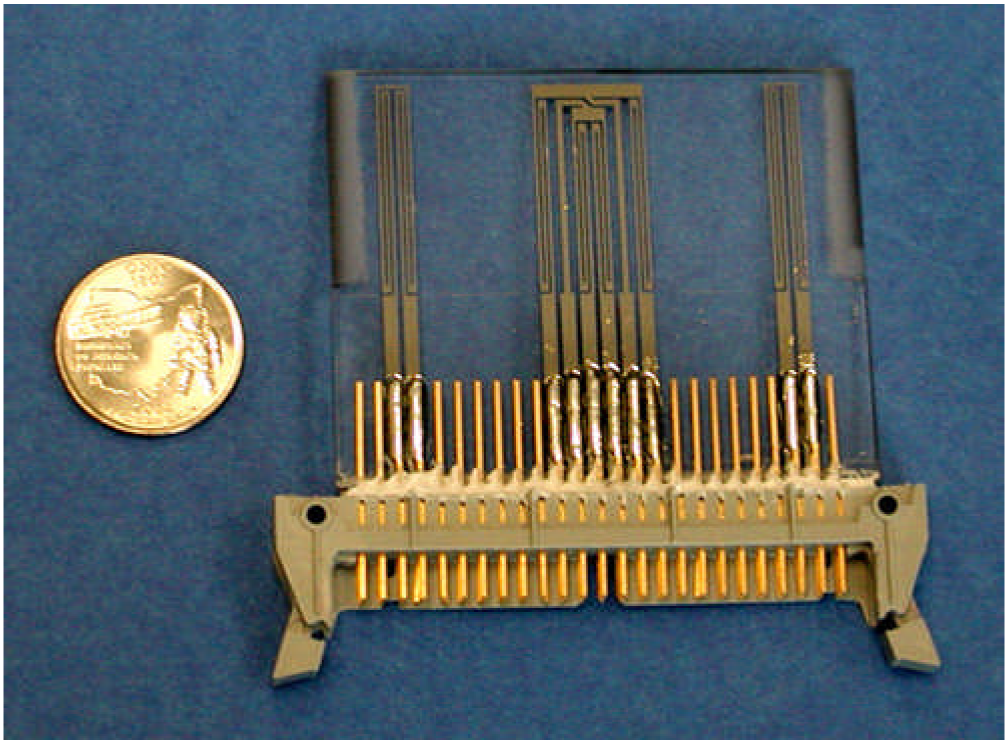
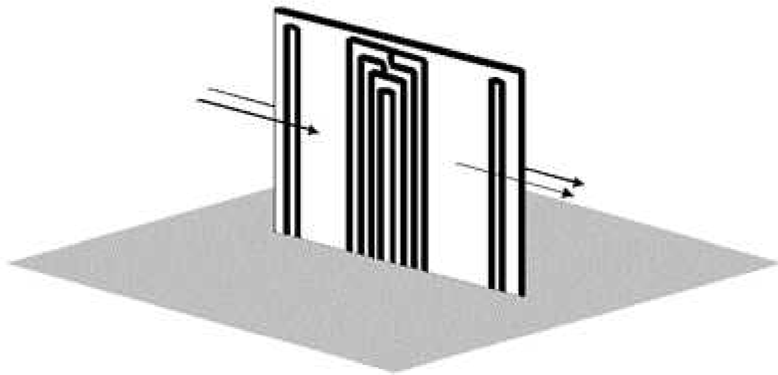
Thin-Film Air-Mass-Flow Sensor of Improved Design Developed

Researchers at the NASA Glenn Research Center have developed a new air-mass-flow sensor to solve the problems of existing mass flow sensor designs. NASA's design consists of thin-film resistors in a Wheatstone bridge arrangement. The resistors are fabricated on a thin, constant-thickness airfoil to minimize disturbance to the airflow being measured. The following photograph shows one of NASA's prototype sensors. In comparison to other air-mass-flow sensor designs, NASA's thin-film sensor is much more robust than hot wires, causes less airflow disturbance than pitot tubes, is more accurate than vane anemometers, and is much simpler to operate than thermocouple rakes.



Thin-film air-mass-flow sensor of improved design.

NASA's thin-film air-mass-flow sensor works by converting the temperature difference seen at each leg of the thin-film Wheatstone bridge into a mass-flow rate. The following figure shows a schematic of this sensor with air flowing around it. The sensor operates as follows: current is applied to the bridge, which increases its temperature. If there is no flow, all the arms are heated equally, the bridge remains in balance, and there is no signal. If there is flow, the air passing over the upstream legs of the bridge reduces the temperature of the upstream legs and that leads to reduced electrical resistance for those legs. After the air has picked up heat from the upstream legs, it continues and passes over the downstream legs of the bridge. The heated air raises the temperature of these legs, increasing their electrical resistance. The resistance difference between the upstream and downstream legs unbalances the bridge, causing a voltage difference that can be amplified and calibrated to the airflow rate. Separate sensors mounted on the airfoil measure the temperature of the airflow, which is used to complete the calculation for the mass of air passing by the sensor.



NASA's thin-film air-mass-flow sensor with air flowing around it.

A current application for air-mass-flow sensors is as part of the intake system for an internal combustion engine. A mass-flow sensor is used to provide accurate information about the amount of air entering the engine so that the amount of fuel can be adjusted to give the most efficient combustion. The ideal mass-flow sensor would be a rugged design that minimizes the disturbance to the flow stream and provides an accurate reading of both smooth and turbulent flows; NASA's design satisfies these requirements better than any existing design. Most of the mass-flow sensors used today are the hot wire variety. Hot wires can be fragile and cannot accurately measure a turbulent or reversing flow, which is often encountered in an intake manifold. Other types of mass-flow sensors include pitot tubes, vane anemometers, and thermocouple rakes-all of which suffer from some type of performance problem. Because it solves these performance problems while maintaining a simple design that lends itself to low-cost manufacturing techniques, NASA's thin-film resistance temperature detector air-mass-flow sensor should lead to more widespread use of mass-flow sensors.

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