Design and Characterization of Robust Hot Film Sensors for Tactical Aircraft Inlets

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Robust hot film sensors capable of withstanding the environmental hazards common to tactical aircraft while meeting the performance requirements for use in an active control system were developed and tested. The usefulness of such robust sensors was demonstrated by employing hot film sensors in the separated flow region of a small-scale Uninhabited Combat Air Vehicle (UCAV) inlet to show that such sensors can provide real time information about the steady and unsteady separation induced distortion at the aerodynamic interface plane (AIP).

Robust hot film sensors with 0.2 micrometer thick evaporated Nickel sensor elements on 635 micrometer thick quartz substrates with 2 micrometer thick Aluminum Oxide protective coatings, gold leads, and aspect ratios ranging from 12.5 to 20 were developed. These sensors were tested for Temperature Coefficient of Resistivity (TCR) time stability, steady-state sensitivity, dynamic response, and sand abrasion resistance. The robust sensors exhibited a maximum TCR variation of 0.32 percent over a simulated period of 500 hours of aircraft operation and 82 percent of the laminar flow steady-state sensitivity value of comparable unprotected sensors. The protective coating did not affect the sensor amplitude and phase response at frequencies less than 1000 Hertz and 600 Hertz respectively. The robust sensors on average lasted more than 21 minutes (the equivalent of over 500 hours of aircraft operation) in sand abrasion tests at the maximum sand particle velocities and concentration possible in the actual full-scale UCAV inlet without a significant change in resistance.

Experiments were conducted on a one-sixth scale model of a UCAV with a hot film sensor array lining the separated flow region of the inlet and unsteady total pressure probes located in regions of high unsteadiness at the AIP. A characteristic frequency consistent with vortex shedding from the separated flow region was present in the inlet for mass flows from 2.9 to 3.4 pounds per second. In the characteristic frequency band, the hot film sensors along the stagnation line at the leading edge of the separated flow region were highly correlated to the unsteady total pressure probes at the AIP. The maximum cross-correlation and coherence values between the hot film sensors and the AIP probes were 0.68 and 0.95 respectively.

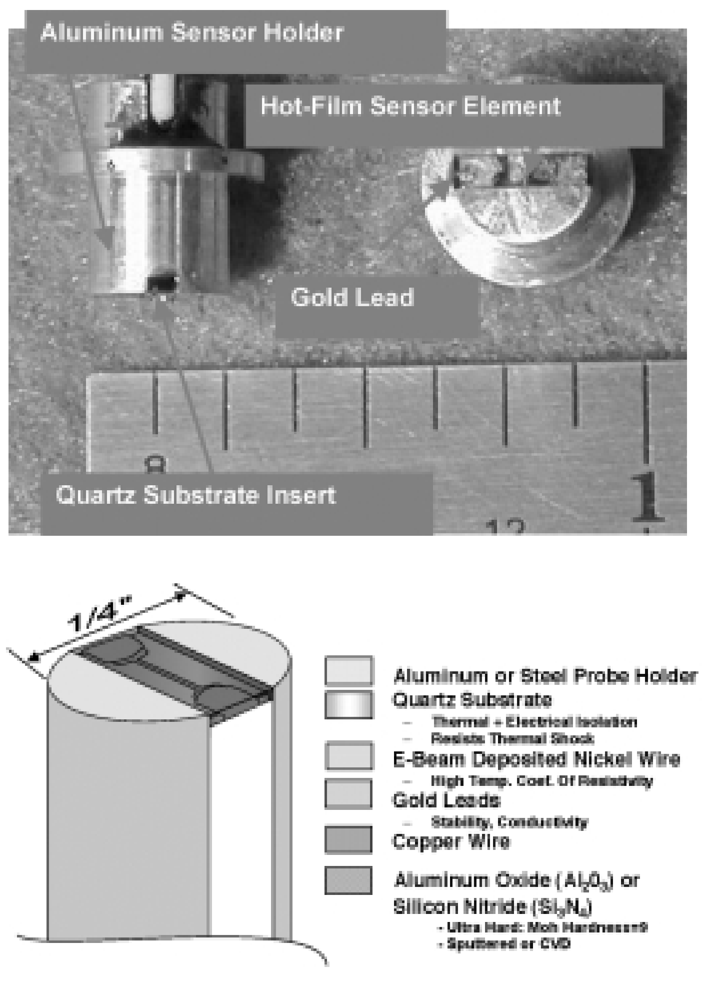

Fig. 32: