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May 1971

Brief 71-10114

NASA TECH BRIEF

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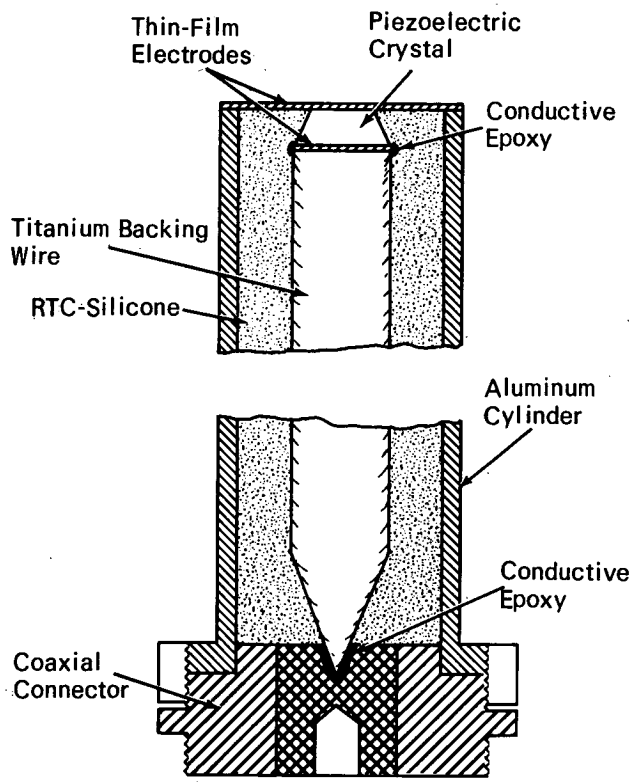
Subminiature Transducer Measures Unsteady Pressures

A subminiature transducer measures hypersonic boundary-layer fluctuating pressures having frequency components ranging from 1 to 500 kHz. The sensing element of the transducer is a thin, piezoelectric



wafer in the shape of a conical frustum. The overall transducer is approximately 0.32 cm (1/8 in.) in diameter and 3.81 cm (1.5 in.) in length. The piezoelectric sensing element, a 0.051-cm (0.020-in.)-thick crystal of lead zirconate titanate, is cut as a conical frustum having base angles of 1.31 radians (75°). This geometry was selected in order to ensure that the plane pressure-wave energy incident on the small-diameter face of the crystal would travel in an optimal path through the crystal and backing material, which is a titanium wire with a sharpened point. The pressure-wave energy propagates through the titanium wire by multiple reflections from its lateral surfaces to the sharpened point, where the energy is mostly dissipated as heat. Titanium was selected as the backing material because it closely matches this piezoelectric crystal in acoustic impedance, thus ensuring maximum energy transfer.

The sensing crystal and the titanium wire are embedded in a room-temperature-curing (RTC) silicone to protect them from mechanical shock and vibration. Thin-film electrodes of silver, 5 to 10 nm (50 to 100 Å) thick, deposited by sputtering on the parallel faces of the crystal, are of such small mass that their effect on the natural frequency of the crystal is negligible. Electrically conductive epoxy resin is used to cement the silvered base of the crystal to the large-diameter end of the titanium wire and also to cement the pointed end of the wire to the central pin of the miniature coaxial connector at the base of the transducer. The thin film of silver on the small-diameter face of the crystal extends to the outer diameter of the aluminum cylinder to form one of the conductors for the piezoelectric signal generated by the crystal. The other conductor is the central pin of the miniature coaxial connector.

To use the transducer for unsteady-pressure measurement, the unit is connected directly to a field effect transistor (FET) emitter follower and the output terminals of the emitter follower are connected to a high-gain, low-noise amplifier. The volt-

(continued overleaf)

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age output from the amplifier, corresponding to the pressures sensed by the transducer, is fed to a recording system having adequate frequency response.

In preliminary experiments, the unamplified output from the transducer ranged from 4 to 10 mV for a pressure of 5.3 N/m^2 (0.04 torr). The measured time rise of the instrument was approximately 0.8μs. The transducer was found to be insensitive to mechanical vibrations of the instrument plug on which it was mounted.

Notes:

1. For better acoustic matching, the sputtered thin-film electrodes on the crystal can be titanium instead of silver.
2. Other metals (e.g., brass, silver, aluminum) can be used for the backing wire, though they would be less efficient than titanium. A ceramic tube with an elastomer-filled core and a conductive-material surface coating can also be used in place of the titanium backing wire.
3. Requests for further information may be directed to:

   Technology Utilization Officer
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   Reference: TSP71-10114

Patent status:

No patent action is contemplated by NASA.

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(ARC-10349)