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**A MICROSEISMOMETER FOR TERRESTRIAL AND EXTRATERRESTRIAL APPLICATIONS.** W. Banerdt, W. Kaiser, and T. Van Zandt, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, USA.

The scientific and technical requirements of extraterrestrial seismology place severe demands on instrumentation. Performance in terms of sensitivity, stability, and frequency band must match that of the best terrestrial instruments, at a fraction of the size, mass, and power. In addition, this performance must be realized without operator intervention in harsh temperature, shock, and radiation environments. These constraints have forced us to examine some fundamental limits of accelerometer design in order to produce a small, rugged, sensitive seismometer.

Silicon micromachined sensor technology offers techniques for the fabrication of monolithic, robust, compact, low-power and -mass accelerometers [1]. However, currently available sensors offer inadequate sensitivity and bandwidth. Our implementation of an advanced silicon micromachined seismometer is based on principles developed at JPL for high-sensitivity position sensor technology. The use of silicon micromachining technology with these new principles should enable the fabrication of a  $10^{-11}$  g sensitivity seismometer with a bandwidth of at least 0.01 to 20 Hz. The low Q properties of pure single-crystal silicon are essential in order to minimize the Brownian thermal noise limitations generally characteristic of seismometers with small proof masses [2].

A seismometer consists of a spring-supported proof mass (with damping) and a transducer for measuring its motion. For long-period motion a position sensor is generally used, for which the displacement is proportional to the ground acceleration. The mechanical sensitivity can be increased either by increasing the proof mass or decreasing the spring stiffness, neither of which is desirable for planetary applications. Our approach has been to use an ultra-sensitive capacitive position sensor with a sensitivity of better than  $10^{-13}$  m/Hz $^{1/2}$ . This allows the use of a stiffer suspension (leading to a wider operating bandwidth and insensitivity to physical shock) and a smaller proof mass (allowing lower instrument mass).

We have built several prototypes using these principles, and tests show that these devices can exhibit performance comparable to state-of-the-art instruments. The total volume of the final seismometer sensor is expected to be a few tens of cubic centimeters, with a total mass and power consumption of approximately 100 g and 100 mW.

**References:** [1] Petersen K. E. (1982) *Proc. IEEE*, 70, 420.  
[2] Melton B. S. (1976) *Rev. Geophys. Space Phys.*, 14, 93.

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**THE HYDICE INSTRUMENT DESIGN AND ITS APPLICATION TO PLANETARY INSTRUMENTS.** R. Basedow, P. Silverglate, W. Rappoport, R. Rockwell, D. Rosenberg, K. Shu, R. Whittlesey, and E. Zalewski, Hughes Danbury Optical Systems, Inc., Danbury CT 06810-7589, USA.

(HYDICE) instrument represents a significant advance in the state of the art in hyperspectral sensors. It combines a higher signal-to-noise ratio (SNR) and significantly better spatial and spectral resolution and radiometric accuracy than systems flying on aircraft today. The need for "clean" data, i.e., data free of sampling artifacts and excessive spatial or spectral noise, is a key driver behind the difficult combination of performance requirements laid out for HYDICE. Most of these involve the sensor optics and detector. This paper presents an optimized approach to those requirements, one that comprises pushbroom scanning, a single, mechanically cooled focal plane, a double-pass prism spectrometer, and an easily fabricated yet wide-field telescope. Central to the approach is a detector array that covers the entire spectrum from 0.4 to 2.5  $\mu$ m. Among the major benefits conferred by such a design are optical and mechanical simplicity, low polarization sensitivity, and coverage of the entire spectrum without suffering the spectral gaps caused by beam splitters. The overall system minimizes interfaces to the C141 aircraft on which it will be flown, can be calibrated on the ground and in flight to accuracies better than those required, and is designed for simple, push-button operation. Only unprocessed data are recorded during flight. A ground data processing station provides quick-look, calibration correction and archiving capabilities, with a throughput better than the requirements. Overall performance of the system is expected to provide the solid database required to evaluate the potential of hyperspectral imagery in a wide variety of applications.

HYDICE can be regarded as a testbed for future planetary instruments. The ability to spectrally image a wide field of view over multiple spectral octaves offers obvious advantages, and is expected to maximize science return for the required cost and weight.

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**RUGGED, NO-MOVING-PARTS WINDSPEED AND STATIC PRESSURE PROBE DESIGNS FOR MEASUREMENTS IN PLANETARY ATMOSPHERES.** A. J. Bedard Jr.<sup>1</sup> and R. T. Nishiyama<sup>2</sup>, <sup>1</sup>NOAA/ERL/Wave Propagation Laboratory, Boulder CO 80303, USA, <sup>2</sup>Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado/NOAA, Boulder CO 80309, USA.

Instruments developed for making meteorological observations under adverse conditions on Earth can be applied to systems designed for other planetary atmospheres. Specifically, a wind sensor developed for making measurements within tornados [1] has no moving parts, detecting induced pressure differences proportional to wind speed. Addition of strain gauges to the sensor would provide wind direction. The device can be constructed in a rugged form for measuring high wind speeds in the presence of blowing dust that would clog bearings and plug passages of conventional wind speed sensors.

Sensing static pressure in the lower boundary layer required development of an omnidirectional, tilt-insensitive static pressure probe [2]. The probe provides pressure inputs to a sensor with minimum error and is inherently weather-protected. Both the wind