



Foam Sensor Structures Would Be Self-Deployable and Survive Hard Landings

NASA's Jet Propulsion Laboratory, Pasadena, California

A document proposes systems of sensors encased in cold hibernated elastic memory (CHEM) structures for exploring remote planets. The CHEM concept was described in two prior *NASA Tech Briefs* articles, including "Cold Hibernated Elastic Memory (CHEM) Expandable Structures" (NPO-20394), Vol. 23, No. 2 (February 1999), page 56 and "Solar Heating for Deployment of Foam Structures" (NPO-20961), Vol. 25, No. 10 (October 2001), page 36. To recapitulate: Lightweight structures that can be compressed for storage and later expanded, then rigidified for use are made

from foams of shape-memory polymers (SMPs). According to the instant proposal, a CHEM sensor structure would be fabricated at full size from SMP foam at a temperature below its glass-transition temperature (T_g). It would then be heated above T_g and compacted to a small volume, then cooled below T_g and kept below T_g during launch, flight, and landing. At landing, the inelastic yielding of the rigid compacted foam would absorb impact energy, thereby enabling the structure to survive the landing. The structure would then be solar heated above T_g , causing it to revert to its origi-

nal size and shape. Finally, the structure would be rigidified by cooling it below T_g by the cold planetary or space environment. Besides surviving hard landing, this sensor system will provide a soft, stick-at-the-impact-site landing to access scientifically and commercially interesting sites, including difficult and hard-to-reach areas.

This work was done by Witold Sokolowski and Eric Baumgartner of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30654

Real-Gas Effects on Binary Mixing Layers

NASA's Jet Propulsion Laboratory, Pasadena, California

This paper presents a computational study of real-gas effects on the mean flow and temporal stability of heptane/nitrogen and oxygen/hydrogen mixing layers at supercritical pressures. These layers consist of two counterflowing free streams of different composition, temperature, and density. As in related prior studies reported in *NASA Tech Briefs*, the governing conservation equations were the Navier-Stokes equations of compressible flow plus equations for the conservation of total energy and of chemical-species masses. In these equations, the expressions for heat fluxes and chemical-species mass fluxes were de-

rived from fluctuation-dissipation theory and incorporate Soret and Dufour effects. Similarity equations for the streamwise velocity, temperature, and mass fractions were derived as approximations to the governing equations. Similarity profiles showed important real-gas, non-ideal-mixture effects, particularly for temperature, in departing from the error-function profile, which is the similarity solution for incompressible flow. The temperature behavior was attributed to real-gas thermodynamics and variations in Schmidt and Prandtl numbers. Temporal linear inviscid stability analyses were performed using the simi-

larity and error-function profiles as the mean flow. For the similarity profiles, the growth rates were found to be larger and the wavelengths of highest instability shorter, relative to those of the error-function profiles and to those obtained from incompressible-flow stability analysis. The range of unstable wavelengths was found to be larger for the similarity profiles than for the error-function profiles.

This work was done by Nora Okong'o and Josette Bellan of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-40162

Earth-Space Link Attenuation Estimation via Ground Radar Kdp

Lyndon B. Johnson Space Center, Houston, Texas

A method of predicting attenuation on microwave Earth/spacecraft communication links, over wide areas and under various atmospheric conditions, has been developed. In the area around the ground station locations, a nearly

horizontally aimed polarimetric S-band ground radar measures the specific differential phase (Kdp) along the Earth-space path. The specific attenuation along a path of interest is then computed by use of a theoretical model of

the relationship between the measured S-band specific differential phase and the specific attenuation at the frequency to be used on the communication link. The model includes effects of rain, wet ice, and other forms of precipitation.

The attenuation on the path of interest is then computed by integrating the specific attenuation over the length of the path. This method can be used to determine statistics of signal degradation on Earth/spacecraft communication links. It can also be used to obtain real-time es-

timates of attenuation along multiple Earth/spacecraft links that are parts of a communication network operating within the radar coverage area, thereby enabling better management of the network through appropriate dynamic routing along the best combination of links.

This work was done by Steven M. Bolen and Andrew L. Benjamin of Johnson Space Center and V. Chandrasekar of Colorado State University. Further information is contained in a TSP (see page 1). MSC-23340

Wedge Heat-Flux Indicators for Flash Thermography

Lyndon B. Johnson Space Center, Houston, Texas

Wedge indicators have been proposed for measuring thermal radiation that impinges on specimens illuminated by flash lamps for thermographic inspection. Heat fluxes measured by use of these indicators would be used, along with known thermal, radiative, and geometric properties of the specimens, to estimate peak flash temperatures on the specimen surfaces. These indicators would be inexpensive alternatives to high-speed infrared pyrometers, which would otherwise be needed for measur-

ing peak flash surface temperatures. The wedge is made from any suitable homogeneous material such as plastic. The choice of material is governed by the equation given below. One side of the wedge is covered by a temperature sensitive compound that decomposes irreversibly when its temperature exceeds a rated temperature (T_{rated}). The uncoated side would be positioned alongside or in place of the specimen and exposed to the flash, then the wedge thickness (d) at the boundary between

the white and blackened portions measured. The heat flux (Q) would then be estimated by

$$Q = (c\rho/\epsilon_b)(T_{\text{rated}} - T_{\text{ambient}})d,$$

where c and ρ are the specific heat and mass density, respectively, of the wedge material; ϵ_b is the emissivity of the black layer of the sheet material, and T_{ambient} is the ambient temperature.

This work was done by Ajay M. Koshti of Boeing Co. for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23056

Measuring Diffusion of Liquids by Common-Path Interferometry

Diffusivities are computed from time series of interferograms.

John H. Glenn Research Center, Cleveland, Ohio

A method of observing the interdiffusion of a pair of miscible liquids is based on the use of a common-path interferometer (CPI) to measure the spatially varying gradient of the index of refraction in the interfacial region in which the interdiffusion takes place. Assuming that the indices of refraction of the two liquids are different and that the gradient of the index of refraction of the liquid is proportional to the gradient in the relative concentrations of either liquid, the diffusivity of the pair of liquids can be calculated from the temporal variation of the spatial variation of the index of refraction. This method yields robust measurements and does not require precise knowledge of the indices of refraction of the pure liquids. Moreover, the CPI instrumentation is compact and is optomechanically robust by virtue of its common-path design.

The two liquids are placed in a transparent rectangular parallelepiped test cell. Initially, the interface between the liquids is a horizontal plane, above

which lies pure liquid 2 (the less-dense liquid) and below which lies pure liquid 1 (the denser liquid). The subsequent interdiffusion of the liquids gives rise to a gradient of concentration and a corresponding gradient of the index of refraction in a mixing layer. For the purpose of observing the interdiffusion, the test cell is placed in the test section of the CPI, in which a collimated, polarized beam of light from a low-power laser is projected horizontally through a region that contains the mixing layer.

The CPI used in this method is a shearing interferometer. Like other shearing interferometers, this CPI can also be characterized as a schlieren interferometer because its optical setup is partly similar to that of schlieren system. However, the basic principle of operation of this CPI applies to the case in which refraction is relatively weak so that unlike in a schlieren system, rays of light propagating through the test cell can be assumed not to be bent, but, rather, delayed (and correspondingly changed in phase) by

amounts proportional to the indices of refraction along their paths. After passing through the test cell, the beam is focused on a Wollaston prism, which splits the beam into two beams that are slightly displaced from each other. When the beams are recombined, they produce interference fringes that indicate gradients of refraction in the test cell. A charge-coupled-device (CCD) camera captures the interferograms, and a video recorder stores them for later analysis.

The interferometer optics are arranged for operation in a mode, known in the art as the finite-fringe mode, in which equidistant, parallel interference fringes appear when the index of refraction in the test cell is uniform (as is the case when only one fluid is present). When a second liquid is introduced and diffusion occurs, the deviation or shift of a fringe from its undisturbed location is a measure of the gradient of the index of refraction in the test cell. For the purpose of this method, it is assumed that the index of