This **Apparatus for Measuring Dispersion** in the device under test is the same as that used in the unmodified AM method, except for the inclusion of the buffer.

dispersion and affords a measurement range from about 2 ps/nm to several thousand ps/nm with a resolution of 0.27 ps/nm or finer.

The figure schematically depicts the measurement apparatus. The source of light for the measurement is a laser, the wavelength of which is monitored by an optical spectrum analyzer. A light-component analyzer amplitude-modulates the light with a scanning radio-frequency signal. The modulated light is passed through a buffer (described below) and through the device under test (e.g., an optical fiber, the dispersion of which one seeks to measure), then back to the light-component analyzer for spectrum analysis.

Dispersion in the device under test gives rise to phase shifts among the carrier and the upper and lower sideband components of the modulated signal. These phase shifts affect the modulation-frequency component of the output of a photodetector exposed to the signal that emerges from the device under test. One of the effects is that this component goes to zero periodically as the modulation frequency is varied. From the basic equations for dispersion of the modulated signal and the amplitude of the modulation-frequency output of the photodetector, the following equation has been derived:

$$D_T = \frac{(2n-1)c}{2\lambda^2 f_n^2},$$

where D_T is the total dispersion, n is an integer, c is the speed of light, λ is the laser wavelength, and f_n is the nth modulation frequency for which the photodetector output vanishes.

One of the conclusions that one can draw from the foregoing equation is that the lower limit of measurability in the AM method is set by the highest modulation frequency. For example, in the case of an apparatus that lacks a buffer but is otherwise identical to that shown in the figure and that has a maximum modulation frequency of 20 GHz and a laser wavelength of 1,550 nm, the minimum measurable dispersion is about 160 ps/nm.

What distinguishes the present method is the inclusion of the buffer, which can be an optical fiber, a fiber-optic grating or a combination of the two. The buffer must have a known dispersion, D_B, approximately equal to or larger than the minimum measurable dispersion. One can determine D_B from a measurement performed without the device under test (that is, the buffer only) in the optical train. When both the buffer and the device under test are present, the total dispersion is given by

$$D_T = D_B + D_{DUT} = \frac{(2n-1)c}{2\lambda^2 f_n^2},$$

where D_{DUT} is the dispersion of the device under test. Then

$$D_{DUT} = D_T - D_B = \frac{(2n-1)c}{2\lambda^2 f_n^2} - D_B.$$

By virtue of the subtraction of D_B, the lower limit of measurability of D_{DUT} is lower than that of D_T. If the symbol of the dispersion is small, one can obtain it by measuring the change in f_n (df_n) and then calculating it approximately as the differential of the immediately preceding equation:

$$dD_T = -2D_T \, df_n / f_n.$$

This work was done by Shouhua Huang, Thanh Le, and Lute Maleki of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Probe for Sampling of Interstitial Fluid From Bone

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus characterized as both a membrane probe and a bone ultrafiltration probe has been developed to enable *in vivo* sampling of interstitial fluid in bone. The probe makes it possible to measure the concentration of calcium and other constituents of the fluid that may be relevant to bone physiology. The probe could be especially helpful in experimental studies of microgravitational bone loss and of terrestrial bone-loss disease states, including osteoporosis.

The probe can be implanted in the bone tissue of a living animal and can be used to extract samples of the interstitial bone fluid from time to time during a long-term study. The probe includes three 12-cm-long polyacrylonitrile fibers configured in a loop form and attached to polyurethane tubing [inside diameter 0.025 in. (0.64 mm), outside diameter 0.040 in. (1 mm)]; the attachment is made by use of a 1-cm-long connecting piece of polyurethane tubing [inside diameter 0.035±0.003 in. (0.89±0.08 mm), outside diameter 0.060±0.003 in. (1.52±0.08 mm)]. At the distal end, a 2-cm-long piece of polyurethane tubing of the same inner and outer diameters serves as a connector to a hub. A 1-cm-long piece of expanded poly (tetrafluoroethylene) tubing over the joint between the fibers and the connecting tubing serves as a tissue-ingrowth site.

This work was done by Elsa M. Janle of Bioanalytical Systems, Inc., for **Johnson Space Center**. *For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-23044*