

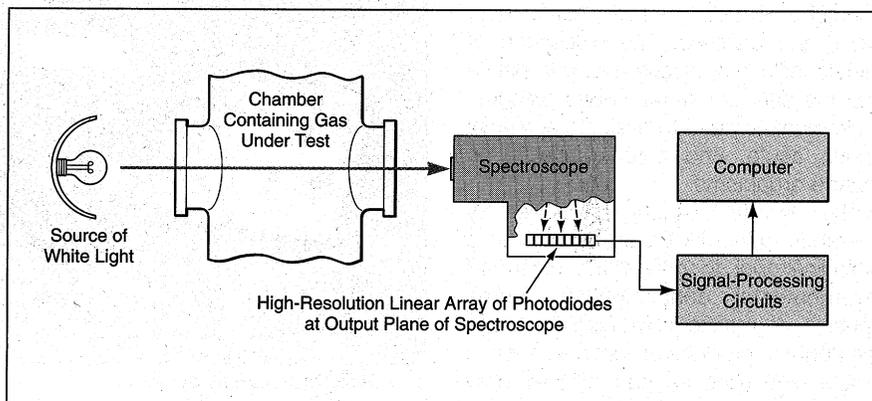
Spectroscopic Measurement of Temperature and Pressure of O₂

Measurements can be taken nonintrusively during pneumatic impact.

Lyndon B. Johnson Space Center, Houston, Texas

A spectroscopic technique (see figure) has been found to be useful in measuring the temperature and pressure of oxygen in laboratory experiments that involve high temperatures and/or high pressures. This technique was devised especially for use in experiments in which oxygen or a gas that contains oxygen is subjected to sudden adiabatic compression, as in a shock tube. This technique might also be useful in combustion experiments and other experiments in which gaseous oxygen plays a role.

This spectroscopic technique exploits temperature and pressure dependences of the absorption spectrum of the oxygen-complex molecules that form during adiabatic compression. The intensities of the double electronic absorption spectral peaks are approximately proportional to the square of the pressure, and these peaks are broadened to approximately Gaussian shapes that can be evaluated in terms of the temperature dependence of Doppler



Spectroscopy is used to measure the temperature and pressure of oxygen undergoing sudden adiabatic compression. As in other applications of spectroscopy to measurement of physical conditions in gases, the principal advantage of the use of spectroscopy (instead of solid probes) in this application is nonintrusiveness.

broadening. Furthermore, collisionally induced electronic transitions to normally spin-forbidden states have been observed, and the profiles of the P and R branches exhibit a temperature dependence consistent with a Boltzmann population distribution.

This work was done by Ralph M. Tapphorn, Dwight D. Janoff, and Norman J. Armendariz of Lockheed Engineering & Sciences Co. for Johnson Space Center. For further information, write in 116 on the TSP Request Card. MSC-21908

Digital Image Analysis of Coloration in Dyed Textiles

A simple new method detects color defects in wool-cotton blend fabrics.

Agricultural Research Service (ARS), Eastern Regional Research Center (ERRC), Philadelphia, Pennsylvania

Researchers at the US Dept. of Agriculture's ARS ERRC have developed a quick and efficient method to detect color defects in dyed textiles, one that complements conventional colorimetric instrumentation relying on color parameters to describe quality and depth of shade. Despite the recognition of wool/cotton as a desirable and unique product, limited sources for apparel, fabric, and yarns impede its availability and thus its acceptance. Part of the sourcing problem can be tied to the difficulty of dyeing wool/cotton by a simple and easy process.

The image analysis system was configured simply on a solid-state charge-coupled device (CCD) camera linked to a PC containing a framegrabber board for analog-to-digital conversion of a fabric's image. The software, run from a Windows environment, provides utilities for the access, process, display, and

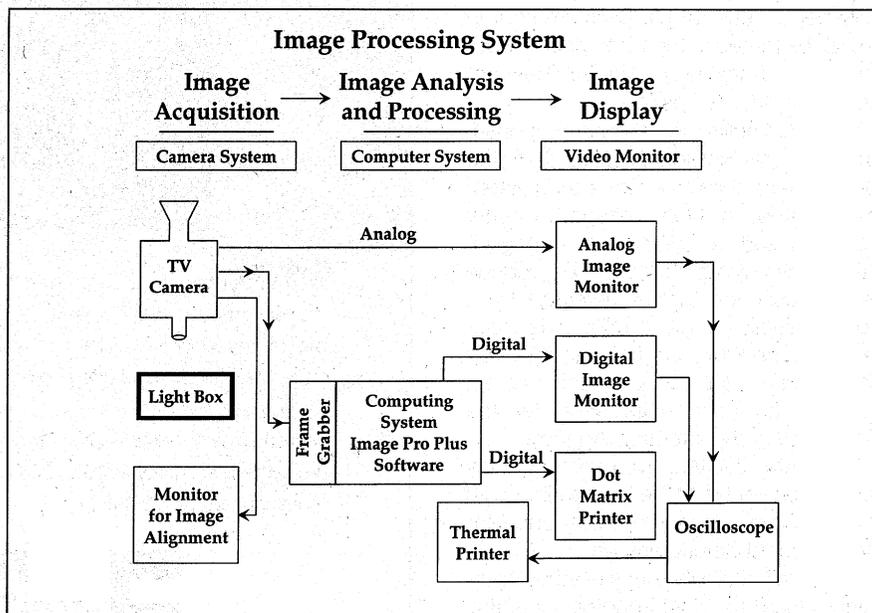


Figure 1. Schematic of the system for detecting uniform coloration in dyed textiles.

A Bioassay for Assessing Marine Contamination

Bioluminescence helps determine whether a targeted area needs remediation.

Naval Command, Control and Ocean Surveillance Center (NCCOSC), San Diego, California

It has become increasingly important to be able to quickly assess the toxic content of test samples with confidence, ease, and success. The dispersion of metals, effluents, discharges, and paints into the earth's natural waters presents an immediate need to evaluate sublethal acute, acute, and chronic effects on marine organisms.

The Qwiklite bioassay, developed by the laboratory at NCCOSC, is used as a biological tool to gauge the extent of environmental contamination. Some species of marine phytoplankton have the ability to produce bioluminescence, a visible blue light, as part of their daily physiological process. The ecological role these minute organisms play as primary producers in the ocean makes them ideal subjects and biological tools in many laboratory situations.

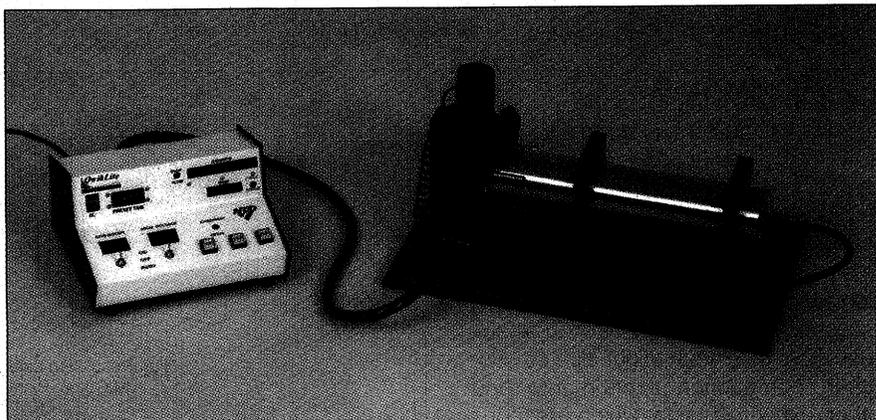
The Qwiklite bioassay determines acute response and chronic effects of a wide variety of toxicants upon bioluminescent dinoflagellates by measuring their light output after exposure. Successful bioassays of this type have been performed on the bioluminescent dinoflagellate *Gonyaulax polyedra*. The use of bioluminescent dinoflagellates, as part of a broader-based biological and chemical testing program, can help identify a potential problem.

Sea water and appropriate amounts of toxicants are mixed and distributed into optical-grade spectrophotometric plastic cuvettes. Dinoflagellate cells are added to produce a concentration of about 300 cells per cuvette (3 ml). Cells are kept in the dark to allow for dark phase optimization (maximum bioluminescent potential) prior to testing.

When sampling for a dose response, cuvettes are individually placed in the Qwiklite test chamber. Once the system is activated, a high voltage, a timer counter, and a stirrer are engaged. Stirring stimulates the cells to produce bioluminescence that is detected by a photomultiplier tube (PMT). The data recorded as PMT counts can then be converted to an endpoint such as an IC50 or as toxic units used by the Environmental Protection Agency.

The data resulting from this bioassay have been found to be compatible with data derived from shrimp, fish, and bioluminescent bacteria assays.

Extreme sensitivity is achieved by operating close to single-photon counting mode. A direct-drive stirring system with



The Qwiklite bioassay system.

adjustable-speed motor uses a stainless steel shaft terminating in a plastic propeller. Other technical features are a fully adjustable timer and automated data acquisition cycle. The PMT is an RCA 8575 with S-20 response and is horizontally mounted alongside a cradle for the propeller. Dimensions of the Qwiklite controller are 21 X 25 X 15 cm. The mounted PMT chamber is 30 X 50 X 24 cm.

*This work was done by David Lapota, Hugh Copeland, Gary Mastny, Dena Rosenberger, and Debbie Duckworth at the **Naval Command, Control and Ocean Surveillance Center, RDT&E Division**. For information about possible licensing and commercialization partnerships, contact David Lapota, NCCOSC RDT&E DIV 0143, 53560 Hull St., San Diego, CA 92152-5001; (619) 553-2798.*

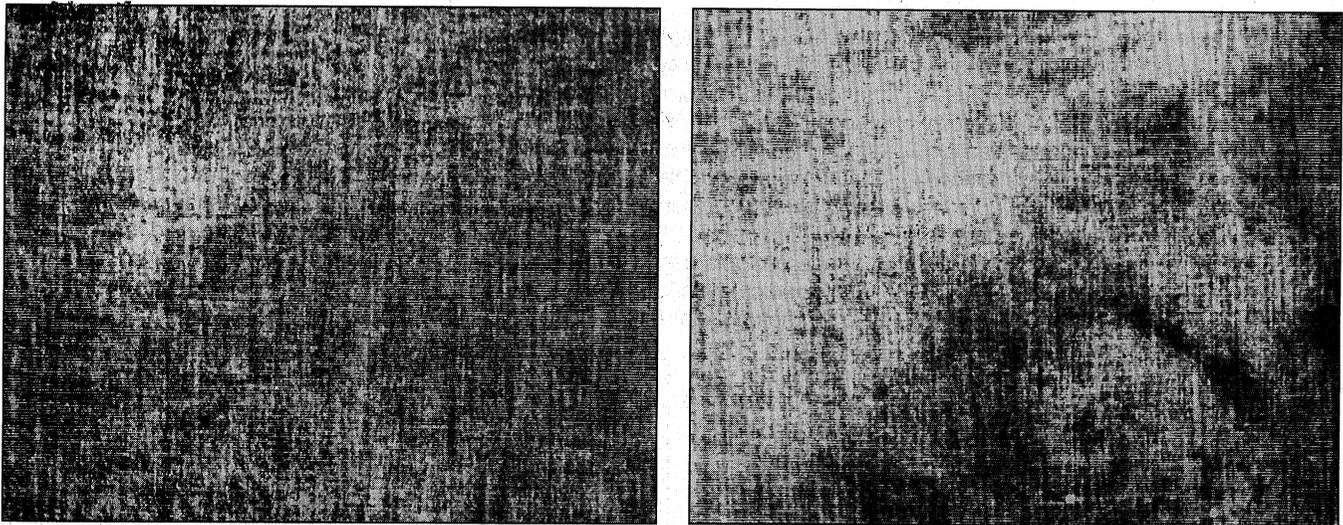


Figure 2. Photographic prints of the **video display images** of D80 (level, left) and D81 (unlevel) dyed fabrics.

manipulation of a fabric's achromatic image. The analog image of a colored fabric, displayed in shades of gray, is converted to a digital form from which data are acquired. This data can be displayed in histogram format as a frequency distribution of pixels along a gray scale of 256 brightness levels. The system is shown schematically in Figure 1.

The USDA team chemically modified cotton to make it equally competitive with wool in the dyebath. Chemical modification of cotton can occur in a pretreatment step before dyeing. The researchers borrowed the fabric pretreatment technology of using resin-amine. This technology was developed to form cationic cotton by researchers in the Textile Finishing Chemistry research unit at USDA ARS's Southern Regional Center in New Orleans.

In the wool/cotton fabric, cationic cotton will dye like wool in acidic medium with acid, direct, and reactive dyes because the amine groups on

wool become cationic under these dyebath conditions. Such pretreatments involve pad/dry/cure conditions favorable to wool.

Examination of the union cloth—having a set of wool yarns interlaced in the weaving with a set of cotton yarns—for union (one) shade involves visually comparing the sets of wool and cotton fringes. Subjective inspection, however, is seriously flawed because it is only human and leaves latitude for interpreting what constitutes a defect in a dyed textile and what the tolerance threshold for acceptance should be.

By contrast, image analysis can be used to follow the effectiveness of pretreatment processes such as the pad/dry/cure or its alternative, wet/cold batching (currently under investigation) for producing uniform fabric dyeing. It offers a new level of objectivity and accuracy, and can be readily adapted for on-line inspection without the costly investment of commercially available systems embodying sophisticated

algorithms that emulate the human vision system.

The studies applied image analysis to two different systems:

- the dyeing of cotton fabric to *level shade* for uniform coloration, and
- the dyeing of 50%/50% wool/cotton fabric to *union shade* for one color on both the wool and cotton yarns.

Figure 2 shows 100% dyed cotton fabric imaged by the system shown in Figure 1. The digital images in Figure 2 represent pixel distribution over the gray scale range for uniform or level-dyed fabric (D80) and for nonuniform or unlevel-dyed fabric (D81). The image of D81 appears relatively more uneven than D80; visually, fabric D80 is uniformly dyed and fabric D81 is splotchy in color.

Figure 3 shows how to emphasize these differences with binary images and segmentation obtained by highlighting only those pixels covering a narrow range of gray levels. The region selected for D81 was where the unlevel-

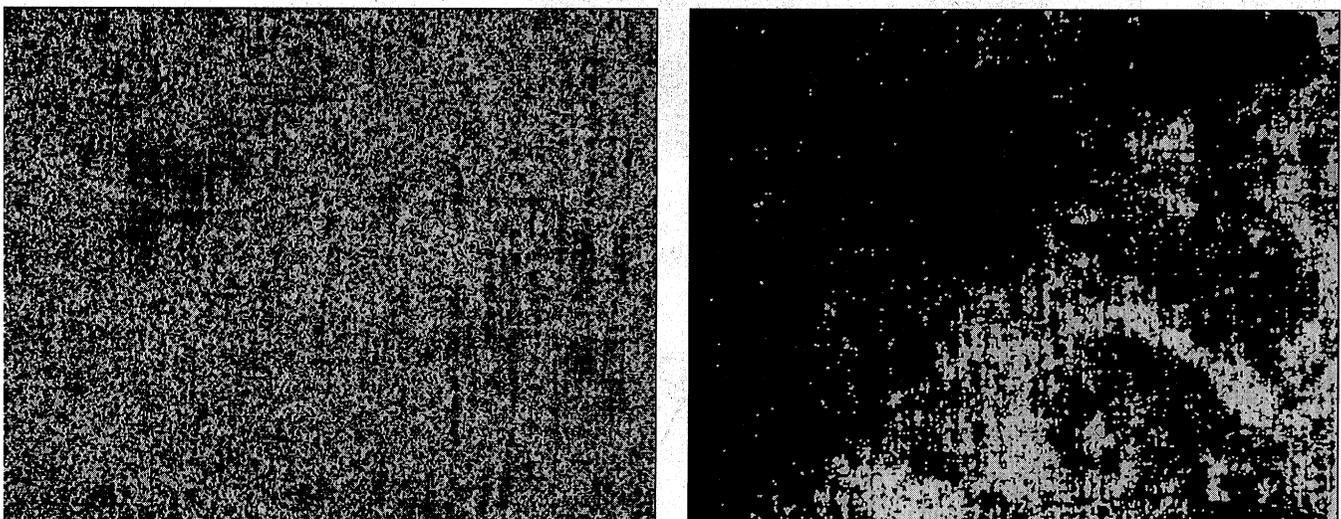


Figure 3. **Binary images** of D80 (level, left) and D81 (unlevel) segmented from the digital images.

ness was most pronounced. Now the differences between D80 for level shade and D81 for unlevel are more obvious.

The extent of levelness or unlevelness of D80 and D81 dyed fabrics can be measured from the standard deviations of their histograms, shown in Figure 4. One can derive a simple equation where the standard deviations are compared with those of either an 18% reflectance graycard or a visually perceived level-

dyed fabric. The narrow distribution of pixels around the gray-scale average for the graycard would give the lowest standard deviation. Note that the pixel distribution (and thus standard deviation) for level D80 fabric is broader than the graycard but narrower than that of unlevel D81 fabric.

Image analysis can also be used not only to indicate uniformity of color but also the actual color brightness or light-

ness as determined from the histogram's gray-scale mean. In this sense, image analysis for recording color uniformity would complement colorimetric measurement for determining color quality in the industrial dye range.

To obtain union shades, resin-amine pretreatment was applied to wool/cotton fabrics before dyeing. Figure 5 shows the histograms of these dyed fabrics with and without resin-amine

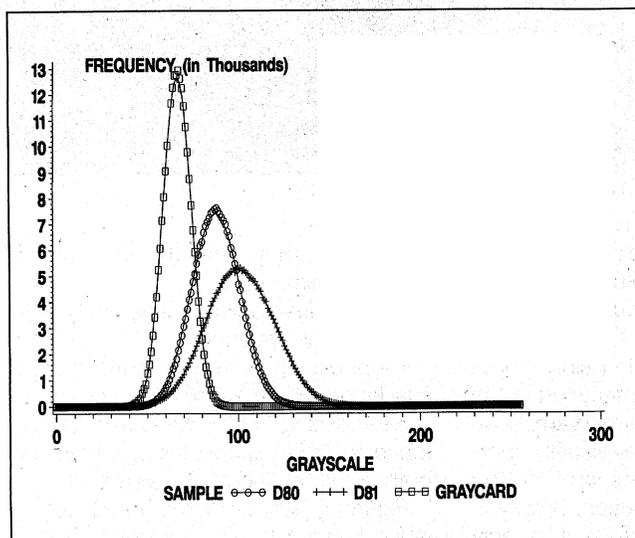


Figure 4. Histograms of gray-scale levels for graycard average, level (D80), and unlevel (D81) fabrics.

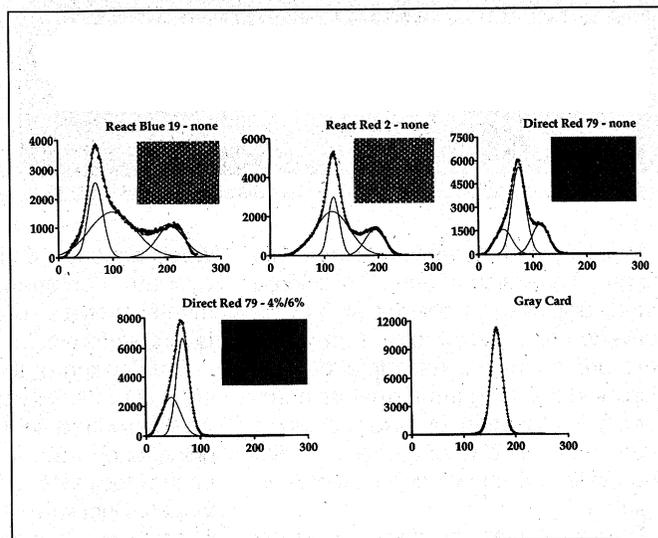


Figure 5. Union shade determination: histograms of dyed wool/cotton union fabric with and without pretreatment.

pretreatments. In the cases of dyeing without pretreatment, the fabrics "React Blue 19—none," "React Red 2—none," and "Direct Red 79—none" the histograms are bimodal because only the wool yarns were dyed. At the camera distance of two inches, dyed and undyed yarns could be resolved. Fabric pretreatment with 4% resin/6% amine as shown in the fabric "Direct Red 79-4%/6%" resulted in the merging of the modes for a union shade. In the case of union shade, the graycard could be used as reference in a simple equation accounting for both gray-scale means and resolved constituent peak areas to arrive at a union shade index.

With digital image analysis and the fabric's histogram, objective measurements of level and union shade are possible. In the case of wool/cotton, by including the distance in gray-scale averages of the constituent peaks and their relative areas, a union shade index can be established.

The researchers believe this new system will provide important guidance for the development of new and useful textile auxiliary products to assist in dyeing because it offers greater utility than standard colorimetric methods in qualifying and quantifying uniformity of shade.

This work was done by Drs. Jeanette M. Cardamone, William C. Damert, and William N. Marmer at the US Dept. of Agriculture's **Agricultural Research Service, Eastern Regional Research Center (ARS ERRC)**.

This image analysis system can be configured from readily available components. The developers welcome the opportunity to collaborate with any company interested in scaling up the technology for use in commercial oper-

ations. Inquiries may be directed to Dr. Stephen H. Fairheller, Technology Transfer Coordinator, at USDA ARS ERRC, 600 E. Mermaid Lane, Philadelphia, PA 19118; (215) 233-6610.

Using Ultrasonic Lamb Waves To Measure Moduli of Composites

Specimens can be characterized nondestructively during fabrication and use.

Lewis Research Center, Cleveland, Ohio

Measurements of broad-band ultrasonic Lamb waves in plate specimens of ceramic-matrix/fiber and metal-matrix/fiber composite materials can be used to determine the moduli of elasticity of the materials. In one class of potential

with the same face of the specimen at a known distance and direction from the first transducer. The measurements yield data on the dispersion of Lamb waves; that is, on the speeds of sound in various acoustic modes that propagate along the

could also use it to monitor the effects of fatigue on the Young's moduli of platelike structural components in aircraft, for example.

The first antisymmetric mode provides data on variations in the shear modulus,

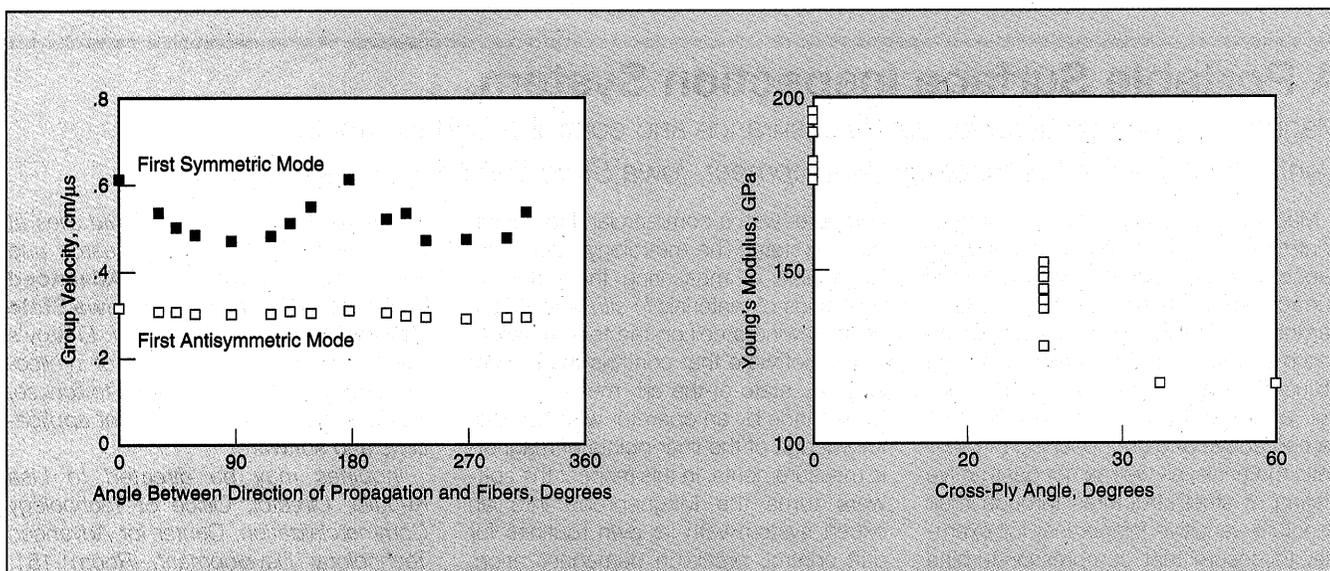


Figure 1. The **Group Velocity** of the first symmetric mode in a panel specimen of a composite of unidirectional SiC fibers in a Ti-15-3 matrix was found to vary with the direction of propagation. This variation is consistent with the Young's moduli of symmetric cross-ply specimens of the same composite with various cross-ply angles.

applications of this concept, Lamb-wave responses of specimens would be measured and analyzed at various stages of thermal and/or mechanical processing to determine the effects of the processing, without having to dissect the specimens. In another class of potential applications, structural components that have shapes that support the propagation of Lamb waves would be monitored ultrasonically to identify signs of deterioration and impending failure.

In the present Lamb-wave analysis method, pulsed acoustic excitation is applied by a first broad-band ultrasonic transducer in contact with one face of a specimen. The acoustic response is measured by use of a second broad-band ultrasonic transducer in contact

surface. The speeds of sound, in turn, can be used to calculate the moduli.

The two most useful Lamb wave modes are the first symmetric and first antisymmetric modes. The speed of sound in the first symmetric mode is a measure of the Young's modulus in the direction of propagation (see Figure 1). Thus, the Young's modulus determined by use of the first symmetric mode depends on the relative positions of the transducers. For example, one could determine the Young's modulus of a tensile specimen along the load-bearing direction, without having to stress the specimen. One could use the first symmetric mode to construct an initial Young's-modulus map of a plate before cutting the plate into specimens. One

or, under some conditions, the flexural modulus with respect to the direction of propagation. Similarly to the case of the first symmetric mode, one could use the first antisymmetric mode to construct a shear- or flexural-modulus map of a plate or to monitor the effects of fatigue on shear or flexural moduli. In addition, experiments have shown that the speed of sound in the first antisymmetric mode in ceramic-matrix composite materials is sensitive to the shear strengths of the interfaces between the matrices and the fibers (see Figure 2).

The Lamb modes are best characterized by constructing dispersion curves. For this purpose, it is necessary to determine the phase velocity for each mode of interest. Previously, this was

done by collecting data from a tone-burst measurement at each frequency of interest. However, collecting data separately at each frequency is a time-consuming task. The advantage of the present broad-band pulse measurement concept is that each pulse contains a range of frequencies, so that each measurement can contain data on all frequencies of interest. To extract these data, the acoustic response signals are processed by software that separates the frequencies, determines the velocities, and plots the dispersion curves. The software provides the speed and automation necessary for application to research on materials and to monitoring of components during service or processing.

This work was done by Harold E. Kautz of **Lewis Research Center**. For further information, **write in 2** on the TSP Request Card. LEW-15907

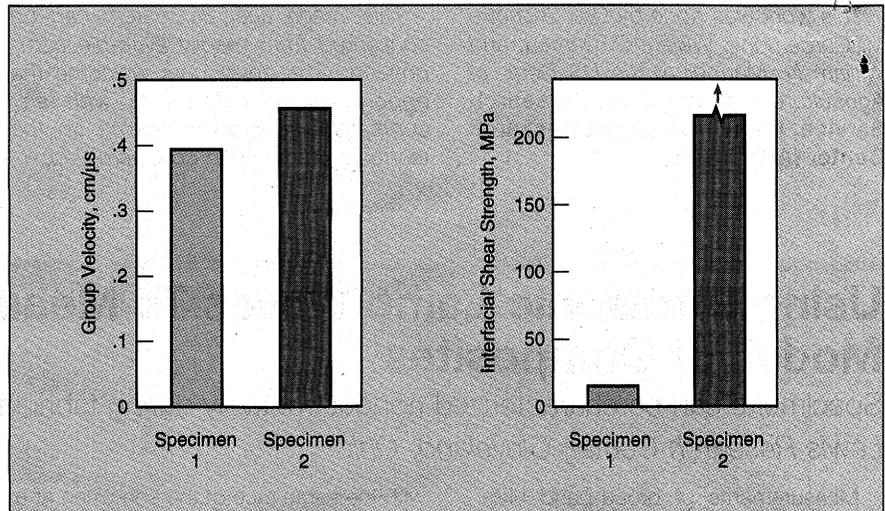


Figure 2. The **Shear Strengths of the Interfaces** between the fibers and matrices in two different composites of silicon carbide fibers in reaction-bonded silicon nitride matrices, as measured by the fiber-push-out method, were found to be semiquantitatively related to each other in the same way as were the group velocities of the first antisymmetric mode in those composites.

A Portable Surface Inspection System

Magneprobe can be used for quality assurance and control of surface treatment.

Center for Advanced Technology Development, Iowa State University, Ames, Iowa

Magneprobe is a portable computer-controlled magnetic inspection system capable of measuring a wide range of surface properties including surface hardness and microstructure hardening depth of materials. The instrument can be used for quality assurance and control of procedures such as the two named above and shot peening of magnetic materials, as well as nondestructive testing of steel structures through their structure-sensitive properties: for example, to ensure that compressor turbine blades have been given the correct heat treatment to minimum acceptable mechanical property standards.

The instrument is lightweight and compact. It is controlled from a small portable

computer with a commercial data acquisition system. The metrology equipment is capable of measuring the magnetic properties of materials *in situ* without the need to wind a coil on the test material.

The software that controls the system enables state-of-the-art measurements to be made by an operator who has little knowledge of the finer points of magnetic measurements. In this respect the software turns the Magneprobe into an expert system with its own routines for drift control, precision demagnetization, and deconvolution of the surface magnetic properties of the test material from the raw data of the measurement and calibration routines for stress detection, for example.

This work was done by David Jiles at the Institute for Physical Research and Technology's **Center for Advanced Technology Development, Iowa State University**, for the Dept. of Energy's Ames Laboratory. A package of intellectual property rights is available to license, including several patents/patent applications and software.

Inquiries may be directed to Lisa Kuuttila, Director, Office of Technology Commercialization, Center for Advanced Technology Development, Room 151, ASC II, Iowa State University, Ames, IA 50011; (515) 294-5121; FAX (515) 294 9519.

Measuring Traces of Oxygen by Resonant Electron Attachment

Relative concentrations below 1 ppb can be detected.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of detecting trace amounts of oxygen is based on dissociative attachment of electrons to oxygen molecules (in the reaction $e^- + O_2 \rightarrow O + O^-$) followed by measurement of the resulting flux of negative oxygen ions in a mass spectrometer. High sensitivity is achieved in this method by exploiting a resonance

in the dissociative attachment of electrons to oxygen molecules: the electron-attachment cross section rises to a high peak at an incident electron kinetic energy of 6.2 eV.

The method was devised to increase the sensitivity of detection of oxygen in processing chambers in which oxygen is

regarded as a contaminant; for example, chambers used in making semiconductor devices and in growing high-purity crystals. The sensors of most commercial instruments designed for measuring traces of oxygen contamination are electrochemical cells. These instruments generally cannot detect oxygen at relative