Wednesday **AFTERNOON**
21 October 1987 **WY**
ERIE CANAL

4:15 PM **Fiber Optics**

Roger Stolen, AT&T Bell Laboratories, Presider

WY1 Reversible optical fiber damage induced by ultraviolet radiation

GREGORY HALL, ELSA GARMIRE, U. Southern California, Center for Laser Studies, Inglewood, CA 90302.

Optical damage resulting from color center formation in fused silica fibers has been investigated at 193 nm. The observance of optical bleaching to reverse the induced absorption is reported for the first time for UV-irradiated fibers. A maximum recovery of 70% initial transmission was obtained when samples damaged by ArF radiation were bleached with 13 J/cm^2 of XeF light. A simple mathematical model, based on the kinetics of color center growth, correlates well with the observed induced absorption curves. Two quantities, the absorption saturation limit and the damage rate constant, characterize the fiber's performance in specified experimental conditions. Their dependence on input fluence, fiber length, and manufacturer is documented. A color center damage threshold near 2 mJ/cm^2 is identified. **(12 min)**

WY2 Time-reversal principle and fiber-optics coupling

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Using very general phase-space formalism applied to a Hamiltonian model of monochromatic light rays with an axial z coordinate as a parameter,[1–3] it is shown that there is a fundamental relation between intrinsic optical losses of expanded-beam fiber-to-fiber coupler/connector and the boundary shape of its 4-D phase-space volume located in the symmetry plane of the system. This relation, based on the so-called time-reversal principle, holds for all axially symmetrical expanded-beam connectors with two twin parts representing the collimator and concentrator. Thus this principle can be applied to any practical fiber–fiber connector including both imaging and nonimaging[2,3] optical systems. The proof of the time-reversal principle is based on comparison of geometrical rays reflected either from phase conjugate or conventional mirrors situated in the symmetry plane of the coupling system (including Liouville theorem). It is shown that for ideal couplers, the angular spectrum of light at any point in the plane of symmetry should have inversion symmetry. **(12 min)**

1. D. Marcuse, *Light Transmission Optics* (Van Nostrand Reinhold, New York, 1982).
2. T. Jannson and R. Winston, J. Opt. Soc. Am. A **3,** 7 (1986).
3. J. Jannson and P. C. Yeung, J. Opt. Soc. Am. A **3,** (13), P68 (1986).

WY3 Generalized gauge-invariant perturbations of optical fibers

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Review of the effects of different perturbations of optical fibers shows that their physical effects are generally identical: that usually is the transfer of the lower-order modes (as measured in the far field) to the higher-order modes of the fiber. This is so for the general classes of microbends, macrobends, pressure variations, temperature variations, and chemical changes. This means that rather than being truly different perturbations, they are physically really the same thing. Each represents a true gauge-invariant perturbation plus a piece that is merely a gauge transformation. Each perturbation is then transformable, and their apparent differences are physically trivial. We take as our points of departure the perturbed fiber discussions of Snyder and Love[1] and Hill's[2] analysis of differential equations from their group invariance properties. We analyze the modal structure of unperturbed fiber in terms of the invariance group of the wave equation for the appropriate fiber geometries and boundary conditions and then show how their perturbations consist of a true physical piece and insignificant parts that are just gauge transformations of each other.

Applications of this to fiber-optic signal-to-noise performance and optical fiber figures of merit are discussed. **(12 min)**

1. A. W. Snyder and J. D. Love, *Optical Waveguide Theory* (Chapman & Hall, London, 1983), Chap. 18, pp. 374–406.
2. J. M. Hill, *Solution of Differential Equations by Means of One-Parameter Group* (Pitman, Boston, 1982).

WY4 Brillouin scattering spectra for oxide and halide glasses: intrinsic Brillouin linewidths and stimulated Brillouin gain

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Brillouin scattering measurements on various multicomponent halide and oxide glass compositions were done as a function of composition, lattice temperature, and configurational temperature. The intrinsic Brillouin linewidth measurements, Brillouin intensities, and Brillouin frequency shifts allowed the calculation of phonon attenuations, the Pockels elastooptic coefficients, and the stimulated Brillouin scattering gain coefficients. From the parameters obtained in the above measurements we are able to calculate the threshold energy for the onset of stimulated Brillouin scattering in halide and oxide glasses. Results show that the threshold power for stimulated Brillouin scattering is larger in some of the halide glass compositions than some of the silica-based glasses. This finding has important ramifications as a selection criteria for halide-based glasses vs oxide based glasses in their use as possible single-mode waveguide materials. The phonon attenuation values of some of the halide glasses, as measured from the linewidth data, had magnitudes that correspond more to a liquid than a solid. These anomalous phonon attenuation findings are discussed in light of existing theories. **(12 min)**

WY5 Fiber-optic gyroscope using a SWAOM: a progress report

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When a laser beam passes through the SWAOM, two laser beams emerge: a diffracted first-order beam ψ_1 and an undiffracted zeroth-order beam ψ_2. The two beams are launched into the opposite ends of a rotating fiber loop. The diffracted beam ψ_1 passes through the rotating fiber loop and then back into the SWAOM. When the beam ψ_1 enters the SWAOM after traversing the fiber loop two beams emerge: a diffracted first-order beam ψ_3, and an undiffracted zeroth-order beam ψ_4. Similary the undiffracted beam ψ_2 passes through the rotating fiber loop and reenters the SWAOM. The beam also becomes two beams, a diffracted beam ψ_5 and an undiffracted beam ψ_6. The two superimposed beams ψ_3 and ψ_5 can be detected by a photodetector.

If the acoustic driving frequency of the SWAOM is ω_s, harmonics of ω_s are contained in the output. These harmonics can be detected and used to measure the rotation. Using this configuration, the optical gyroscope can be simplified. **(12 min)**

WY6 Shifted modulation frequency technique for chromatic dispersion measurements

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A new technique for single-mode fibers chromatic dispersion measurements using phase-shift measurements is presented. The poor dynamic range and the perturbation of the rf interferences are the main drawbacks of the well-known method using a LED filtered by a monochromator as a light source and a vector voltmeter for the phase measurements.[1] These problems are overcome by our technique, which also uses a high-frequency modulated LED whose filtered light is launched into the fiber. This HF modulation gives rise to sensitive phase shifts. But between the fiber and detector the modulation frequency is downshifted to the kilohertz range, which enables a low-frequency ultrasensitive detection scheme to be used. Actual downshifting is performed by an acoustooptic intensity modulator. The acoustooptic modulation frequency is very close but different from the LED frequency, so that sum- and difference-frequency signals are generated which conserve the phase of the initial signal. The LF detector only detects the difference-frequency signal whose phase is measured by a lock-in amplifier.

Group delay measurements, with a 10-ps accuracy were performed in a 200-nm spectral range around 1300 nm and with a 5-nm spectral width. **(12 min)**

1. B. Costa, M. Puleo, and E. Vezzoni, Electron. Lett. **19,** 1074.

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