1971 IEEE Sonics and Ultrasonics Symposium Abstracts

Miami Beach, Fla., December 6–8, 1971

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SESSION A: SPECIAL TUTORIAL

Chairman: H. MATTHEWS, Sperry Rand Research Center, Sudbury, MA 01776.

TUTORIAL

BUBBLE-DOMAIN TECHNOLOGY.

HSU CHANG, IBM Corporation, Systems Development Division, San Jose, California 95114.

The physical phenomena which enable bubble domains to perform the functions of storage, transmission, generation, various logic operations, and display will be reviewed.

To illustrate system applications, some of the above functions are utilized to construct two memories which optimize the sharing of circuits and interconnections after the fashion of a self-contained semiconductor memory chip.

Device structures, suitable magnetic crystals and fabricational methods are then discussed and the current status summarized. Finally, the intrinsic capabilities and limitations of the devices will be assessed.

SURFACE CHARGE DEVICES FOR ANALOG SIGNAL.

JEROME J. TIEMANN, General Electric Corporate Research and Development, Schenectady, New York 12301.

The basic operating principles of surface charge devices will be reviewed, and two surface charge transport structures, the charge coupled device and the surface charge transistor, will be discussed.

Fabrication advantages offered by these new devices will then be described, and the new system trade-offs they permit will be detailed. By looking at these devices from the point of view of these trafe-offs, their applicability to specific areas can be discussed quite generally.

Structures that are specifically designed for particular applications will then be discussed, and the expectations for them, based on the present state of the art, will be presented. Particular emphasis will be placed on clocked analog delay structures that are appropriate for multi-tap transversal filters.

RAPID PROGRESS IN INTEGRATED OPTICS.

P. K. TIEN, Bell Telephone Laboratories, Incorporated, Holmdel, New Jersey 07733.

The field of integrated optics involves the use of methods of integrated micro-circuitry for the development of better and more economical optical systems. Through miniaturization and the application of thin film technology, we forsee batch fabrication of optical devices and circuits. Integrated optics, therefore, is an interdisciplinary science; it involves materials research, film fabrication, electronics and physical optics. The purpose of this paper is to review the rapid progress that has been made in this new field.

Basically, we consider the propogation of light waves in a thin film and their interaction with the material of the film or of the substrate, and, with externally applied electric or microwave fields. Photographs of light waves in amorphous and single-crystal films will be shown. The principles of the light-wave couplers will be described as a mathematical puzzle. A series of slides will illustrate the magic of thin-film optics. The discussion will include waveguide and radiation modes, thin-film prisms, lenses and lasers, materials and losses, light-wave couplers and finally, electrooptical and nonlinear experiments in thin films.

LIQUID CRYSTALS IN ULTRASONIC, ELECTRIC AND OPTICAL FIELDS.

L. E. DAVIS, Department of Electrical Engineering, Rice University, Houston, Texas 77001.

A thermotropic liquid crystal is a phase between the solid and isotropic liquid phases in which, over a particular temperature range, matter assumes the shape of its container (like a liquid), but retains some anisotropy (like a crystal). Many organic compounds exhibit such a mesophase and, depending upon the nature of the molecular order, there are three forms: smectic, nematic and cholesteric. A single compound may exhibit more than one form.

In several industrial and university research groups, liquid crystals are currently being investigated for display applications. The nematic materials may be used as electrically or acoustically addressed light valves, and the cholestric compounds have potential for color-contrast displays. This paper will briefly review some of the properties of liquid crystals and discuss their behavior in ultrasonic, electric and optical fields. Potential applications will be outlined.

Acoustic surface waves and optical guided waves in thin films are conceptually quite similar to each other. Furthermore, because the energy of each type of wave is concentrated near the surface, they can interact with each other efficiently. Experiments involving two types of interactions will be described. In the first case, optical guided waves are deflected by surface acoustic waves.[1] The interaction is the two dimensional analog of deflection of a light beam in a bulk acoustic Bragg cell. This interaction has potential applications for optical and rf signal switching and for integrated acousto-optic signal processing. In the second case an optical guided wave and a surface acoustic wave, propagating colinearly, give rise to a second optical wave propagating in a different waveguide mode.[2] Phase matching conditions are satisfied by utilizing the artificial waveguide dispersion. This experiment is the two dimensional analog of experiments in which a bulk acoustic wave is used to couple ordinary and extraordinary light waves in a birefringent crystal. This interaction can be utilized to realize an electronically tuneable integrated optical filter.

1. L. Kuhn, M. L. Dakss, P. F. Heidrich, and B. A. Scott, Appl. Phys. Letters, *17*, 265 (1970).
2. L. Kuhn, P. F. Heidrich, and E. G. Lean, IBM Report RC 3404, June 1971.

A SCANNING ACOUSTIC MICROSCOPE.* B. A. AULD, P. ASBOE-HANSEN,† J. R. FIENUP, C. G. ROBERTS, D. C. WEBB,†† W. W. Hansen Laboratories of Physics, Stanford University, Stanford, California 94305.

A sensitive acoustic microscope with an anticipated resolution limit of 5 μm is being developed. The microscope, which operates at 1.1 GHz, employs a ZnO transducer to generate a 0.75 cm diameter acoustic beam in a water cell containing the object. The beam propagates through the water cell, casting an "acoustic shadow" onto a large area CdS receiving transducer that is coupled to a dielectric electromagnetic resonator. Through the photoconductive effect a focused laser spot deactivates local regions of the CdS transducer.[1] Scanning the spot synchronously with a CRT display and intensity modulating the display tube with the transducer output generates a visual or photographic picture of the object.

The existing microscope has resolved 50 μm wires with 230 μm spacings, using a 20 second frame time and a microwave power transmission loss < 60 dB. Current performance characteristics, limitations and design considerations will be discussed.

[1] B. A. Auld, D. C. Webb, D. K. Winslow, Proc. IEEE *57*, 713-714 (1969).

*Work supported by John A. Hartford Foundation, Inc.

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A PULSED BRAGG DIFFRACTION METHOD OF ULTRASONIC VISUALIZATION. L. W. KESSLER, A. KORPEL and P. R. PALERMO, Zenith Radio Corporation, Research Department, 6001 W. Dickens Avenue, Chicago, Illinois 60639.

Real time ultrasonic visualization by Bragg diffraction imaging may be useful in medical diagnosis and nondestructive testing. To date, however, only CW acoustic illumination has been employed. In this paper we discuss the novelty of incorporating both sound and light pulsing in order to achieve a range gating effect, and we will present results. The range gate, more appropriately termed a depth of penetration gate, can be varied by altering the delay time between light and sound pulses. In this system interaction between the light and the incident sound on an object imaged in reflection does not interfere with that of the reflected sound. In addition, any undesired strong reflections may be gated out. Thus, this system can be employed as a variable depth "acoustic window" which visualizes cross-sections parallel to the illuminating sound wavefronts. Furthermore, the pulsed system offers an increased depth discrimination which is N times greater than the depth of focus of the CW system. For a simplified case $N = 2\Lambda f^2/P$ where Λ is the acoustic wavelength, f is the "f number" of the optical imaging system and P is the path of the acoustic pulse.

A PULSED INDEX GRADIENT TECHNIQUE FOR APPLICATIONS IN SCANNING. E. H. YOUNG, JR., R. H. JOHNSON, R. M. MONTGOMERY, Radiation Incorporated, Melbourne, Florida 32901.

We have recently demonstrated a pulsed index gradient technique* for modulation and cavity coupling of a laser. This technique can be applied equally well to data scanning. The number of resolvable spots in this scanner approaches $2Tf_0$ where f_0 is the resonant frequency of the transducer. In the experiment the transducer on the dense flint acoustic cell was charged to 160 volts and was then discharged suddenly by the breakdown of avalanche transistors. The transducer responded at its resonant frequency and a few cycles of the acoustic wave propagated into the glass cell. The acoustic strain is the mechanism for the index gradient. For the 20 MHz cell the rise time of the scanned slit was about 20 nsec; a slit size of 100μ could be resolved. A simple model of the device was analyzed; it compared favorably with experimental results.

*R. H. Johnson, E. H. Young, Jr., R. M. Montgomery, "A New Method in Pulse Modulation and Cavity Dumping Lasers," to be presented at the International Electron Device meeting.

A NEW APPROACH TO OPTICAL SCATTER LOSS WHICH EMPHASIZES FUNDAMENTAL MATERIAL PROPERTIES. D. A. PINNOW, Bell Laboratories, Inc., Murray Hill, N.J. 07974.

It is well know that the range of optical transmission through a solid or liquid wave guide is fundamentally limited by the sum of the bulk scattering and absorption losses. However, it is not generally appreciated how these mechanisms relate to material parameters. In the present work the scattering loss in the liquid and vitreous states is formulated in terms of fundamental material properties to provide a guide for materials selection. In particular, it is shown that the scattering loss coefficient in a glass is proportional to the quantity $n^8p^2/\rho V^{-2}(T + T_g)$, where n is the index of refraction, p is the photoelastic component, ρ is the density, V is the sound velocity, and T and T_g are the ambient and glass transition temperatures, respectively. Since this group of parameters is closely related to the acousto-optic figure of merit, $n^6p^2/\rho V^{-3}$, it should not be surprising that the experimental techniques developed for acousto-optical studies are extremely useful for evaluating optical transmission materials. For example, it is shown that the absolute scattering loss coefficient can be determined by the method of spontaneous Brillouin spectroscopy. From the spectral information it is also possible to determine whether this loss is intrinsic or due to other mechanisms such as phase separation in the vitreous state and imperfections in wave guides. Experimental results are presented for several materials including fused silica (5 dB/km at a wavelength of 6328Å) and the general applicability of this work for material selection and evaluation is discussed.

OPTICAL BRAGG DIFFRACTION BY STANDING ULTRASONIC WAVES WITH APPLICATION TO OPTICAL DEMULTIPLEXING.* C. S. TSAI and S. K. YAO, Department of Electrical Engineering, Carnegie-Mellon University, Pittsburgh, Pa. 15213.

Bragg diffraction by standing ultrasonic waves (SUW) has been utilized to gate optical pulse trains. The device configuration employed was that of an ultrasonic beam excited at one end face of an acoustic medium in the shape of a rod, with the standing wave being set up along the rod by reflection from the rod-air interface at the other end. A rigorous calculation using the wave-optic formulation has established the parameters that determine the depth of modulation (the ratio of maximum to minimum light intensities) in the