Modern Optics

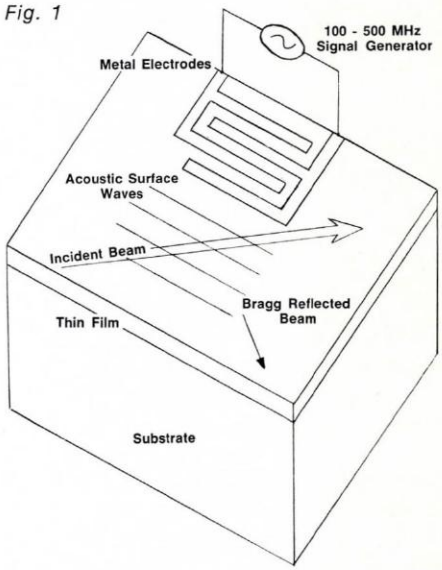
The thirty five papers presented in the Modern Optics Symposium of the conference reflected the diversity of applications of modern optics in almost all branches of both basic and applied research. In addition, progress was reported in increasing the spectral range and tunability of coherent radiation sources both in the UV and the IR. New experimental options and possibilities were created by the perfection of ultra-short laser pulses in the sub-picosecond range.

From a technological point of view, the most significant news concerned the possibility of constructing two dimensional, complex circuitry in which the signal carrier is an optical electromagnetic wave. This has potentially far reaching practical implications, especially in the field of optical communications.

Progress in the development of planar optics benefits from the knowledge and practice acquired in the related technologies of electronic circuit integration and microwave engineering. For instance, essentially the same mathematical formalism describes the propagation of both microwaves and optical waves in waveguides, only the boundary conditions and loss mechanisms being different.

An optical two dimensional waveguide comprises a thin transparent film deposited on a substrate with refractive index higher than that of the film. The velocity of propagation in such a film depends on its thickness, and therefore two dimensional lenses and prisms can be made merely by a local change in the width of the film according to a given pattern. A ray of light can then be focused and deflected in a manner similar to that performed in three dimensions. Amongst the various two dimensional devices that have appeared, the one portrayed in Fig. 1 is of special interest. The thin metal electrodes deposited on the surface of the optical waveguide serve as an acoustic surface wave generator when an electric AC signal is applied to them. An optical beam crossing such a wave undergoes partial Bragg reflection. The direction and the amplitude of the reflected beam for a given incident beam are determined, respectively, by the frequency and the amplitude of the applied AC signal. Such a device can be used to obtain a real time spectrum analyzer of RF signals. With the existing technology, many such two dimensional optical devices can be manufactured as a compact, robust, integrated component, which is similar in appearance to the popular electronic integrated circuit. Such components will undoubtfully compete with the electronic components in many applications.

Fig. 1



Laser Probes

A normally weak Rayleigh scattering can be enhanced considerably by inducing spatial fluctuation in the scattering medium. This effect, called "forced Rayleigh scattering" may be excited by two laser beams incident upon the surface of the medium at slightly different angles so as to produce a stationary interference pattern. The fluctuations may result in inhomogeneities in the concentration of chemical species, vibrationally or electronically excited molecules or simply in variation of the refractive index, which is normally a function of temperature. The amplitude of the steady state temperature fluctuation is proportional to the ratio of the absorption coefficient and the heat conductivity. Such fluctuations are created by a constant illumination of sufficiently long duration. Additional information can be extracted by looking at transient fluctuations induced by shorts pulses. The method is very sensitive, being capable of detecting a 10^{-8} fraction of the incident beam. With such sensitivity it is possible to measure extremely small temperature differences, and variations in absorption coefficient as small as 10^{-7} cm^{-1}. A time resolution in the range of picoseconds is available with ultrashort laser pulses.

Another interesting application concerns the use of submillimeter lasers to study different properties as a function of an external magnetic field, such as the two dimensional free charge carrier gas created on the surface of the semiconductor in a MOS device.

When the surface electric field is high enough, two dimensional energy bands are created. Transitions between those bands can be observed using far infra-red coherent radiation, thus providing information about their structure. When in addition an external powerful magnetic field is applied, new energy levels appear due to the quantization of the motion of the free charge carriers in the magnetic field. Transitions between those levels give rise to the cyclotron resonance, a phenomenum which is well known to occur in the bulk of semiconductors. By observing the cyclotron resonance one can learn much about the effective mass and relaxation time of the free charge carriers in the surface layer. Certain results were interpreted in terms of the creation of a two dimensional Wigner lattice, a structure which was theoretically anticipated many years ago though still lacking a firm experimental basis.

Nonlinear optical materials play an important role in modern optics. By the generation of harmonics, both tunability and spectral range can be extended. The mechanism of optical nonlinearity is understood today to such a degree that by tailoring new materials, the efficency of harmonic generation can be considerably increased.

Image Correction

An interesting technological application of nonlinear optical materials involves the possibility to generate a phase conjugated (time-reversed) image. This technique can be used to reconstruct an image distorted by a dispersive medium. Consider a beam travelling in a distance L in an optical fibre. The image emerging from the fibre is distorted by dispersion; the distorted image is then phase conjugated and injected into a second fibre with identical optical characteristics as the first. After travelling a distance L in the second fibre, the image is reconstructed again. Such a process can be repeated several times to obtain a long, distortionless picture guide.

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