NASA TECH BRIEF

Directional Coupler for Optical Waveguides

The feasibility of transmitting optical energy in single mode through photonic waveguides has been investigated, resulting in the development of a conceptual directional coupler consisting of two types of dielectric based optical waveguides: one a stratified (core) dielectric and the other a mirror wall. An all-dielectric waveguide comprising a core and a cladding region of differing dielectric constants was examined in detail. Each waveguide considered had a core dimension of the order of 100 wavelengths; the difference of dielectric constants between the core and cladding was about 0.0001, which limits propagation to a single mode.

A theoretical analysis of the waveguide medium resulted in the formulation of mode cutoff conditions, field distributions, and propagation characteristics. In the practical embodiment of the bisected waveguide, losses in the metal wall were sufficient for the modes of propagation to be modified from those which would exist with a lossless wall. As a result of tests of additional waveguide configurations, it was found that other optical materials, drawn and fire polished in either slab or circular rod shapes, had variations of dielectric constant that distorted or precluded single-mode propagation.

An investigation of the components in microscopic optical waveguides showed that directional couplers could be designed to enable equal-power split in coupling lengths of less than 3 cm. For waveguide bends, a minimum radius of 50 cm (without reflecting plates) was indicated, although tests showed a somewhat larger radius. Optical resonators in waveguides were found to have spatial characteristics fundamentally different from free-space resonators. It was determined that the common types of amplitude and frequency modulators could be constructed in waveguides; the possibility of operating with a very small volume of electro-optic material allowed large bandwidth with low modulator power. As part of this work, a unique pulse modulator was designed in which the modulation level was essentially independent of modulation voltage. Optical detectors fabricated in a single-mode waveguide proved to be sensitive to the transverse distribution of both the amplitude and phase of a signal.

This study, including associated experiments, showed that microscopic optical waveguides and components were feasible in operation and construction. Also, this concept showed promise of high-performance components for sophisticated laser systems.

Notes:

1. This information will enable the designers of photonic-energy waveguides to use dielectric components more effectively in optical-energy systems. In addition, a more compact, low-noise, high-information density data handling system for computer applications is possible, and should be of interest to designers of computers and process control equipment.
2. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

(continued overleaf)

Reference:

NASA-CR-332 (N66-16086), Development of Macroscopic Waveguide and Waveguide Components for Optical Systems

Patent status:

No patent action is contemplated by NASA.

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