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GRATINGS AND WAVEGUIDES

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OBJECTIVES

Our immediate objective is to understand the limitations of guided-wave and grating coupler devices in their application to optical data storage. Our long-range goal is to develop and validate design codes for integrated optic devices.

PROGRESS

As a member of the short wavelength laser source team (SWAT) our principal research activity has been in the development of numerical models for the design of a blue wavelength integrated optical source for data storage applications. Nanda Ramanujam's research efforts during the last quarter have been focused on designing a polarization-selective Bragg reflector for an extended cavity semiconductor laser using a grating-assisted slab waveguide. This laser acts as a pump for quasi-phasematched second harmonic generation (QPM-SHG) in an indiffused-KTP segmented waveguide. The Bragg reflecting grating is able to effectively discriminate between the TE and TM modal fields and reflects only the TM field, thereby permitting only TM laser operation. Ramanujam is currently exploring designs (such as chirped grating periods) to further increase the reflection bandwidth. During the next quarter, he plans to develop models and design programs for grating-assisted devices on channel waveguides.

Keith Bates continues to work on the variable groove depth grating coupler project. In the past year or so he has made grating couplers that produced near-Gaussian output beams. The fabrication method was based on an idea first suggested by Lifeng Li, i.e., moving a slit with variable dwelling time in front of the resist grating under ion beam bombardment. However, certain imperfections of the stepper motor that was used to drive the slit resulted in some minor intensity fluctuations in the output coupled beam. At the beginning of this year, Kevin Erwin suggested a new method (the invention disclosure is in preparation) to produce the desired variable depth grating. Initial testing of this new idea has shown very promising results. Bates is currently pursuing it.

Despite the advances made during the past 25 years in the electromagnetic theory and numerical modeling of diffraction gratings, certain grating problems remain difficult to solve even on a supercomputer. For example, the problem of plane wave diffraction by a highly conducting metallic grating of arbitrary shape in TM (electric vector perpendicular to the grating grooves) polarization cannot be analyzed by any existing method when the ratio of groove depth to period is greater than 2. Many methods develop numerical instability long before the ratio reaches 2.

Recently, Li has constructed a computer program that is based on the classical modal method, its extension to the conical incidence case, and the *R*-matrix propagation method, which he borrowed from the chemical physics literature. The program approximates an arbitrary grating profile by dividing it into many layers of rectangular gratings. Because of the use of the R-matrix propagation algorithm the program is immune from the usual numerical instabilities associated with the presence of evanescent and anti-evanescent waves in the conventional propagation algorithm. In addition, because of the excellent convergence properties of the classical modal method, Li's new method also exhibits good convergence characteristics when applied to deep metallic gratings in TM polarization. For example, the program can predict diffraction efficiencies of a gold grating of sinusoidal profile and groove depth to period ratio of 100 at a near-infrared wavelength (we realize that such groove depth is not technologically possible.) The program can treat diffraction gratings of arbitrary surface profile, arbitrary refractive index gradients in the direction perpendicular to the grating plane, and arbitrary angle and polarization of the incident plane wave. The program could easily be converted to treat waveguide gratings and, in particular, the segmented planar waveguides of non-rectangular segments and non-uniform index distribution.

This work is being summarized for submission to a journal. The next step will be to extend the model to include anisotropy of the grating material.