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OPTICAL SYSTEM STORAGE DESIGN with DIFFRACTIVE OPTICAL ELEMENTS

Raymond K. Kostuk
Electrical and Computer Engineering Dept. and
the Optical Sciences Center
University of Arizona
Tucson, AZ 85721

Charles W. Haggans
3M Data Storage Diskette and Optical Technology Division
1185 Wolters Boulevard
Vadnais Heights, MN 55110-5128

Optical data storage systems are gaining widespread acceptance due to their high areal density and the ability to remove the high capacity hard disk from the system. In magneto-optical read-write systems a small rotation of the polarization state in the return signal from the MO media (~0.5°) is the signal which must be sensed. A typical arrangement used for detecting these signals and correcting for errors in tracking and focusing on the disk is illustrated in Figure 1. Table 1 lists the components required to achieve these functions. The assembly and alignment of this complex system has a direct impact on cost, and also affects the size, weight, and corresponding data access rates. As a result, integrating these optical components and improving packaging techniques is an active area of research and development.

Most designs of binary optic elements have been concerned with optimizing grating efficiency. However, rigorous coupled wave models for vector field diffraction from grating surfaces[1] can be extended to determine the phase and polarization state of the diffracted field, and the design of polarization components. Figure 2 shows a typical grating geometry and the phase (δ) and polarization (α) angles associated with the incident and diffracted fields. A number of grating parameters can be used to modify the polarization properties and are listed in Table 2.

As indicated, in addition to geometrical factors, the type of interface can also be used to affect the field properties of the diffracted beam. In order to accentuate different polarization effects induced in a beam after interacting with a grating, large angles of incidence (i.e. the angle θ in Figure 2) are required. These angles can be achieved using a beam incident from the substrate of the grating. In addition, fabrication tolerances can be improved if the grating operates on the zero order rather than a higher diffraction order. The grating then serves as a controlled birefringence surface rather than a diffraction grating. This concept is illustrated in Figure 3. At the grating surface a higher effective index exists parallel to the grooves relative to the orthogonal direction. Several aspects of these components were verified experimentally using high spatial frequency lamellar type gratings formed holographically in photoresist. Figure 4 shows a comparison between theory and experiment for the phase (δ) and polarization angle (α) as a function of azimuth angle (Φ). As indicated the comparison is quite good for the dielectric interface case, indicating the utility of coupled wave theory for design.

In the current stage of our work we are examining system configurations which cascade several polarization functions on a single substrate (Figure 5). In this design the beam returning from the MO disk illuminates a cascaded grating element which first couples light into the substrate, then introduces a quarter wave retardation, then a polarization rotation, and finally separates s- and p- polarized fields through a polarization beam splitter. The input coupler and polarization beam splitter are formed in volume gratings, and the two intermediate elements are zero-order elements[2].

Reference

1. Moharam, M. G. and Gaylord, T. K. J. Opt. Soc. Am. 73, 1105-1112 (1983).
2. Haggans, C.W., "Polarization Properties of Zeroth Order Surface-Relief Gratings with Application to Optical Storage Heads," PhD Thesis, Univ. Ariz., 1992.

FIGURE 1 CONVENTIONAL M-O HEAD

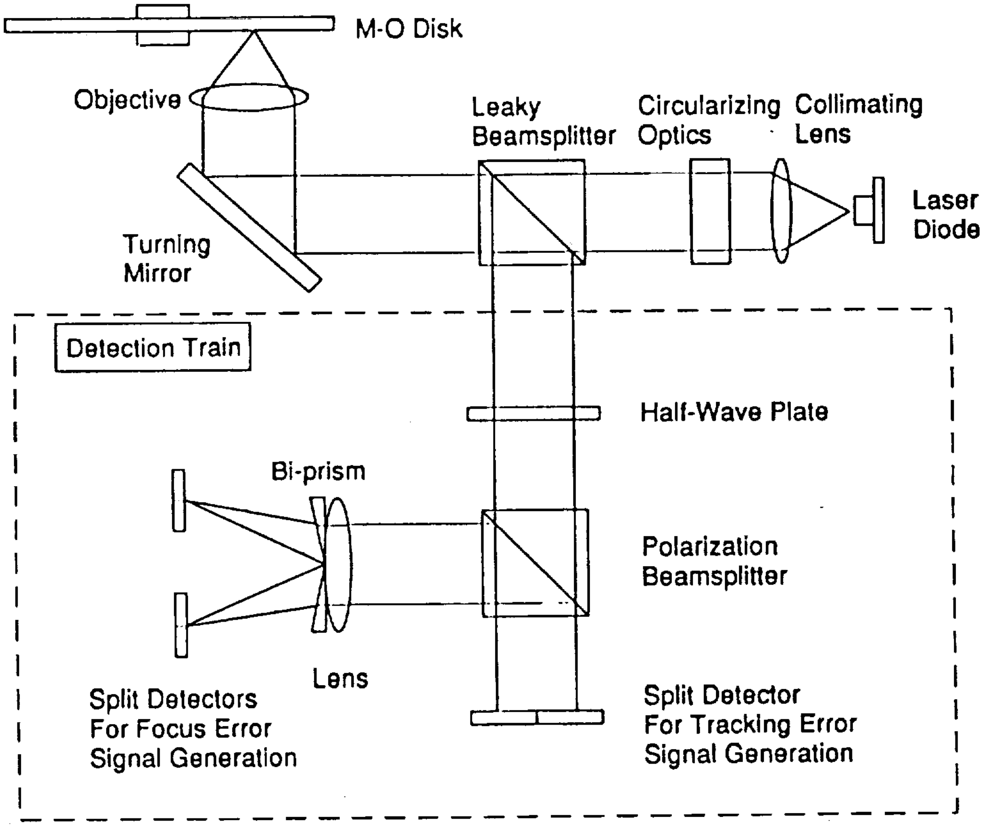


FIGURE 2 GRATING GEOMETRY

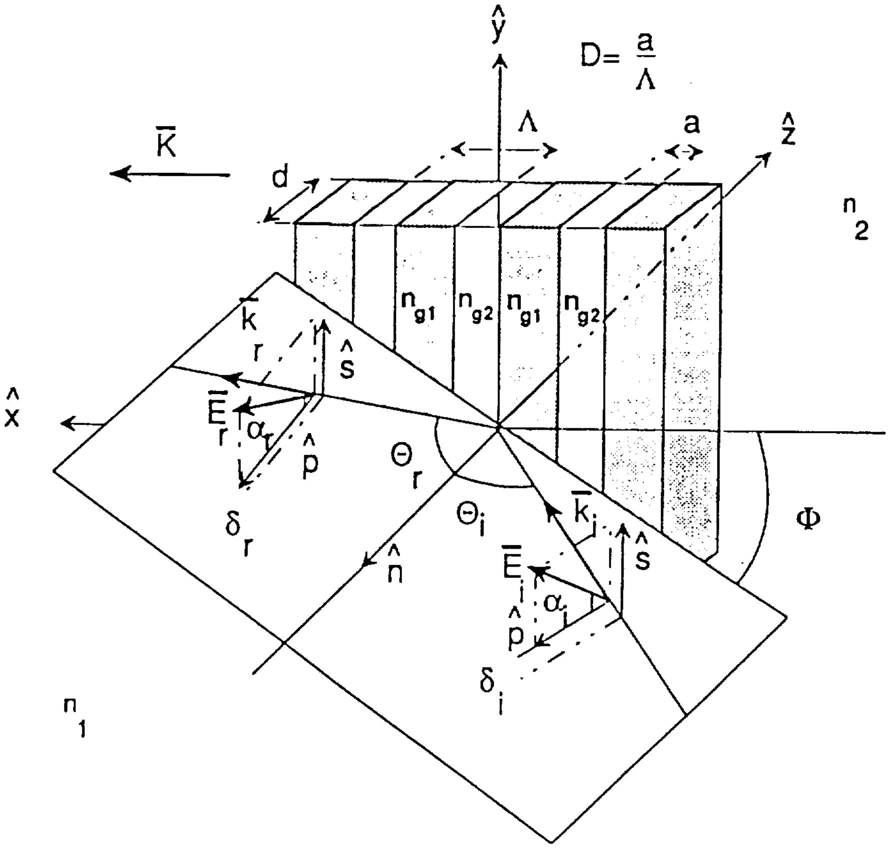
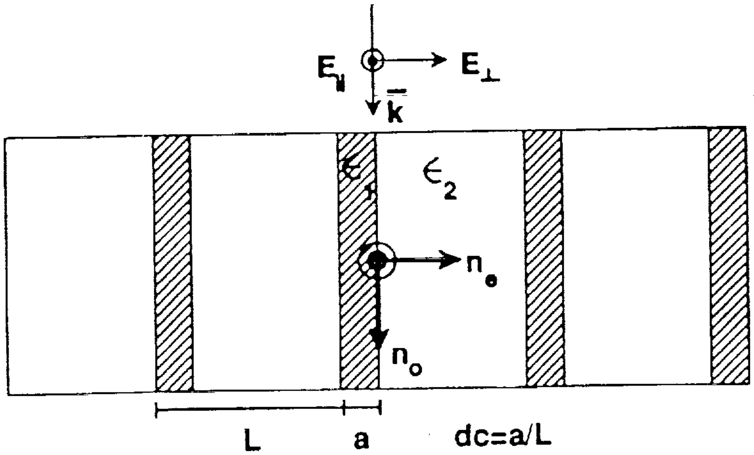


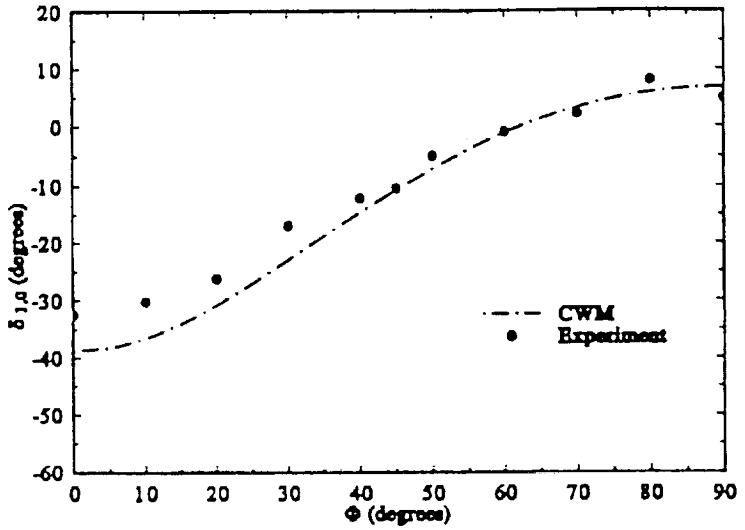
FIGURE 3 ENGINEERED FORM BIREFRINGENCE



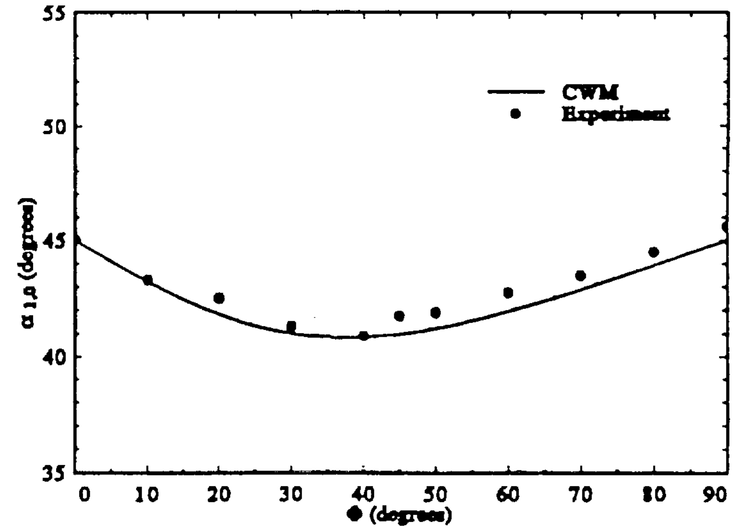
$$\epsilon_\perp = \frac{D}{E_{avg}} = \frac{\epsilon_1\epsilon_2}{dc\epsilon_2+(1-dc)\epsilon_1} = n_e^2$$

$$\epsilon_| = \frac{D_{avg}}{E} = dc\epsilon_1+(1-dc)\epsilon_2 = n_o^2$$

FIGURE 4 MODEL - EXPERIMENT COMPARISONS of GRATING POLARIZATION PROPERTIES



s-p phase difference versus the azimuthal angle of incidence for the zeroth order reflected from the grating of Fig. 5-11. CWM results are for L=1 and N=35.



Amplitude ratio angle versus azimuthal angle of incidence for the zeroth order reflected from the grating of Fig. 5-11. CWM results are for L=1 and N=35.

PROPOSED M-O HEAD

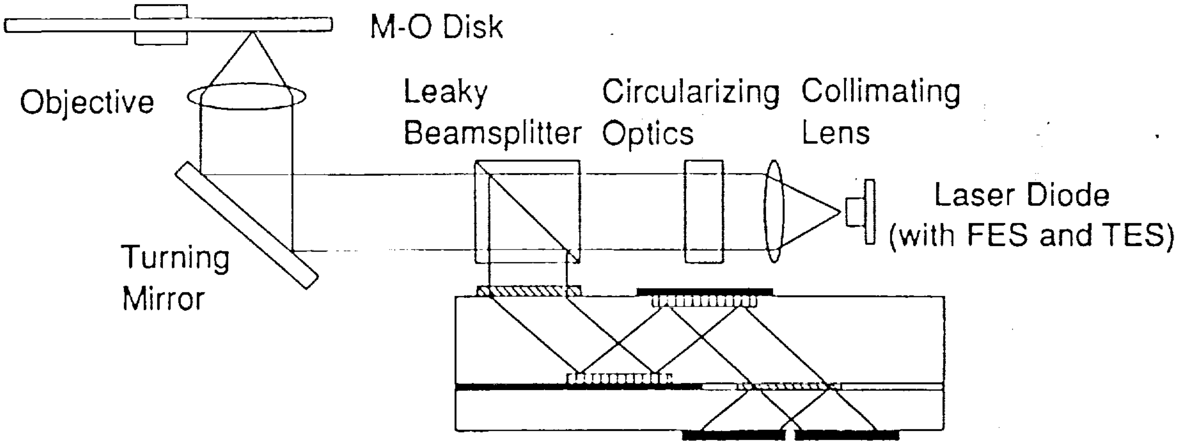


FIGURE 5. Proposed head for using diffractive elements for polarization sensing. The beam returning from the disk is coupled into a substrate, then a quarter wave retarder, a polarization rotator, and a polarization beam splitter before leaving the substrate.

TABLE 1

COMPONENTS REQUIRED for OPTICAL STORAGE SYSTEMS

* HIGH NA OBJECTIVE - PICK UP ELEMENT

* CYLINDRICAL LENSES - QUADRANT DETECTION METHODS

* POLARIZATION COMPONENTS
  - $\lambda/4$ RETARDERS
  - $\lambda/2$ RETARDERS

* POLARIZATION SELECTIVE/NON SELECTIVE BEAM SPLITTERS

* PARTIALLY POLARIZING BEAM SPLITTERS

* BEAM TURNING MIRROR

* CIRCULARIZING PRISM

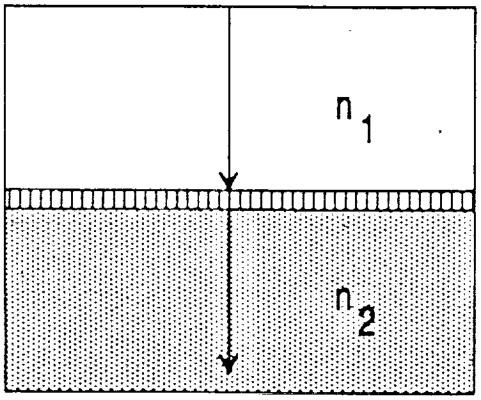
* ANTI REFLECTION COATINGS

* COST/MANUFACTURING CONSTRAINTS

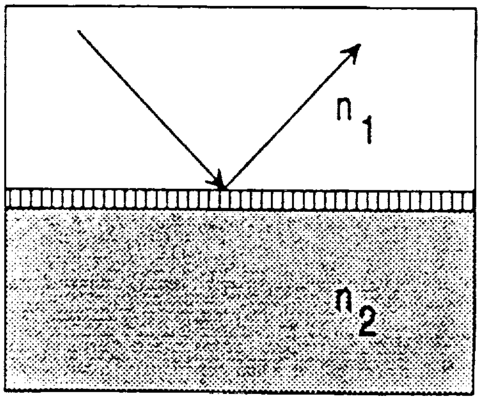
TABLE 2

GRATING DESIGN PARAMETERS

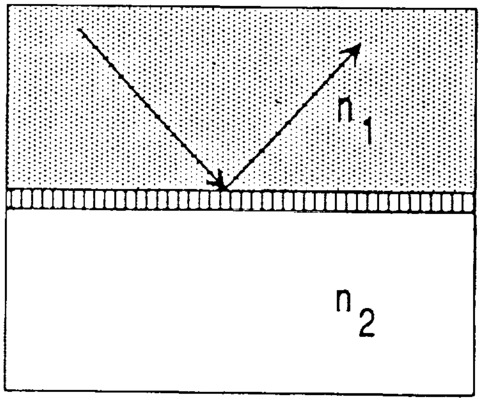
- CONTROLLABLE INPUT VARIABLES
  - * GRATING DEPTH - d
  - * GRATING PERIOD - Λ
  - * DUTY CYCLE - D
  - * OPERATING WAVELENGTH - λ
  - * AZIMUTH ANGLE - Φ
  - * GRATING INTERFACE - DIELECTRIC/DIELECTRIC; DIELECTRIC/METAL; METAL/DIELECTRIC



Dielectric-dielectric grating ($n_1<n_2$).



Dielectric-metallic grating.



Dielectric-dielectric grating ($n_1>n_2$ and $\Theta>\Theta_c$).