Final Report

Technology Development of Stratified Volume Difffractive Optics for Waveguide Coupling

Task Order: H-30199D of BOA NAS8-97095

Principal Investigator: Diana Chambers/UAH/CAO

Technical Monitor: Helen Cole/SD72

This report addresses work performed under BOA NAS8-97095 titled "Technology Development of Stratified Volume Diffractive Optics for Waveguide Coupling." Topics considered were modification of existing, rigorous software design tools to be comparible with a coupling configuration, design of appropriate grating couplers and fabrication techniques necessary to accomplish the grating designs.

Review of waveguide coupling theory and comparison with the rigorous software design tools indicated that no modifications were necessary at this time to design the required gratings. However, interpretation of the input parameters and the output would be different than those used for typical transmission gratings.

A preliminary grating coupler design was generated with the following parameters:

Parameter	Value
Period	1.64 microns
Output Angle	80 deg wrt normal, 10 deg wrt grating
Grating Type	Binary, 50% duty cycle
Number of Grating Layers	3
Thickness of each layer	.075 microns
Grating layer material	TiO2
Homogeneous layer material	SU-8
Grating layer offsets	0 microns
Grating alignment tolerance	~40nm

The performance of this grating is dependent on its length along the waveguide. Initial predictions of greater than 98% efficiency are obtained of grating lengths of 1-2mm. This preliminary design assumed material properties for the waveguide layer as provided by Michael Watson (SD72). While the design appears feasible in terms of feature sizes and grating offsets, it should be revisited prior to fabrication of a demonstration device. In particular, applying offsets to the grating layers may reduce tolerances required on layer alignments.

The primary emphasis of the work under this BOA was development of the fabrication technique to separate grating layers using a homogeneous layer and then align subsequent grating layers within the required tolerance. A photopolymer that is applied by spincoating was determined to be a suitable homogeneous layer separation since it completely filled the grooves of the grating underneath and also planarized well. The technique used to accomplish the alignment is shown in Figure 1. A laser beam is directed through the substrate, which has one or more grating layers on one surface, and also through the mask with a grating pattern on its surface. The mask and substrate are aligned as closely as possible through visual alignment marks and then the substrate is translated with respect to the mask by a high-precision, piezoelectric actuator controlled by a computer. The diffraction signal of the laser beam is detected and recorded on the computer for interpretation. By comparison with simulation, precise alignment of the mask and substrate gratings can occur to achieve the desired offset.

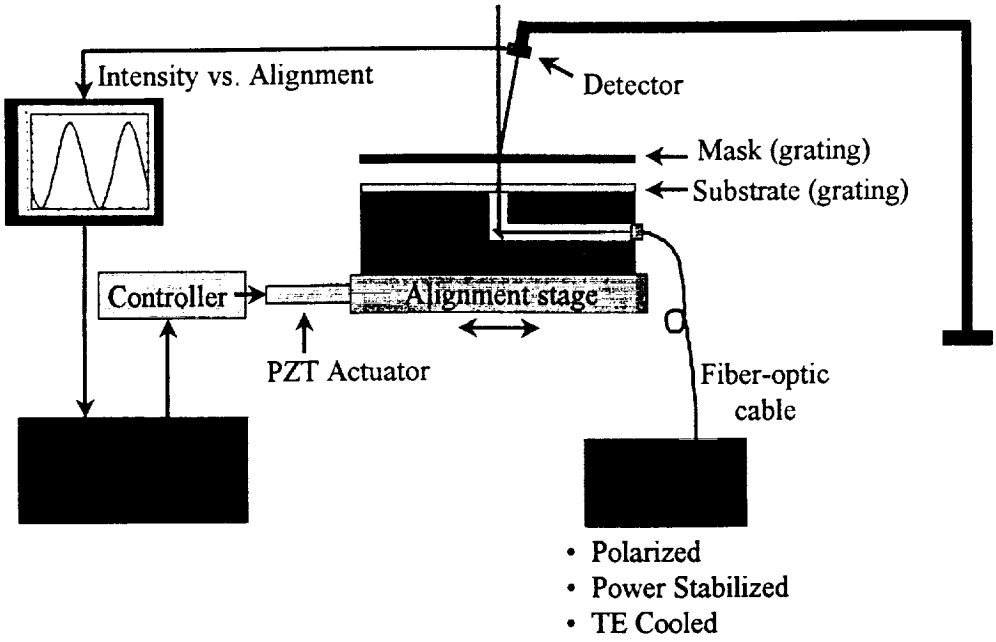
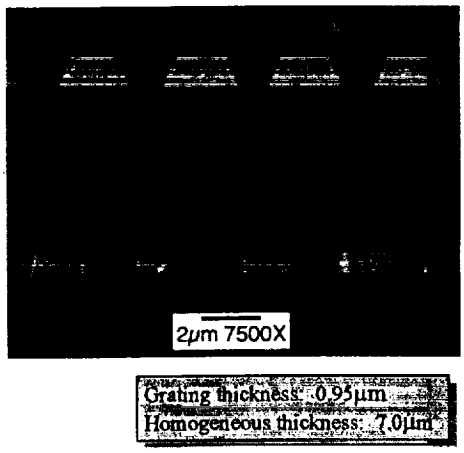


Figure 1. Alignment technique for multiple grating layers

The equipment necessary to implement this scheme has been obtained in cooperation with funding under a cooperative agreement with GHCC. The equipment has been installed on a mask aligner at UAH and software has been written to control its operation. Alignment has been attempted on a number of samples intended for demonstration as a lidar scanning element. The progress for this is outlined in Figure 2.



Alignment Summary

- Offsets applied: 1.15 - 1.85μm
- Tolerance achieved: ± 0.1μm
  Tolerance attempted: ± 0.1μm
- Approaches to achieving required (0.03 - 0.04μm) tolerance:
  - Improve PZT 'creep' compensation
  - Further characterize systematic bias due to mask aligner
  - Refine alignment algorithm

Figure 2. Alignment status.

In conclusion, the technique of Stratified Volume Diffractive Optical Elements (SVDOE's) seems to be feasible for application to waveguide couplers. Preliminary design studies were conducted under this task, but further work should be done prior to fabricating and testing any demonstration elements. The focus of this task has been development and testing of the alignment technique, the most challenging aspect of SVDOE's, for achieving precise alignment, including layer offsets, of the grating layers within SVDOE's. Progress on this aspect has been very favorable with demonstrated tolerances that are much improved over standard diffractive optic alignment techniques.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	5 January 2000	Final 2/26/99 – 9/39/99

4. TITLE AND SUBTITLE
Technology Development of Stratified Volume Diffractive Optics for Waveguide Coupling

5. FUNDING NUMBERS
C #NAS8-97095, TA #H-30199D

6. AUTHORS
Diana M. Chambers

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Alabama in Huntsville
301 Sparkman Drive
Huntsville, AL 35899

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
NASA/Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
Unknown

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified/Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Stratified Volume Diffractive Optical Elements (SVDOE) appear to be viable as high-efficiency waveguide couplers. Preliminary design studies were conducted under this task to provide initial device parameters for evaluation. However, these designs should be revisited prior to fabrication of a device for testing. The emphasis of this task has been development and implementation of fabrication procedures necessary for SVDOE's, namely alignment of grating layers, including offsets, to within required tolerances. Progress in this area indicates that the alignment technique chosen is viable and tolerances have been reached that allow reasonable performance ranges. Approaches have been identified to improve alignment tolerances even further.

14. SUBJECT TERMS
Stratified Volume Diffractive Optical Elements, waveguide couplers, photolithographic alignment

15. NUMBER OF PAGES
2

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR