

---

## **CVC SiC Mirrors for High Energy Laser Applications (Preprint)**

**Colby A. Foss, Jr.**

**Trex Enterprises corporation  
3038 aukele Street  
Lihuc, Kaul HI 96766**

**29 July 2005**

## **Conference Proceedings**

**APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.**



**AIR FORCE RESEARCH LABORATORY  
Directed Energy Directorate  
3550 Aberdeen Ave SE  
AIR FORCE MATERIEL COMMAND  
KIRTLAND AIR FORCE BASE, NM 87117-5776**

---

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

<b>1. REPORT DATE (DD-MM-YYYY)</b> 29-07-2005		<b>2. REPORT TYPE</b> Conference Proceedings		<b>3. DATES COVERED (From - To)</b> April 2004 - April 2005	
<b>4. TITLE AND SUBTITLE</b> CVC SiC Mirrors for High Energy Laser Applications (Preprint)				<b>5a. CONTRACT NUMBER</b> FA9451-04-M-0085	
				<b>5b. GRANT NUMBER</b>	
				<b>5c. PROGRAM ELEMENT NUMBER</b> 65502F	
<b>6. AUTHOR(S)</b> Colby A. Foss, Jr.				<b>5d. PROJECT NUMBER</b> 3005	
				<b>5e. TASK NUMBER</b> DP	
				<b>5f. WORK UNIT NUMBER</b> DN	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Trex Enterprises Corporation 3038 Aukele Street Lihue, Kauai, HI 96766				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Air Force Research Laboratory 3550 Aberdeen Avenue SE Kirtland AFB, NM 87117-5776				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> AFRL/DESE	
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b> AFRL-DE-PS-TP-2007-1002	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for Public Release; Distribution is Unlimited.					
<b>13. SUPPLEMENTARY NOTES</b> Submitted for release to Space and Missile Defense Conference, Mirror Technology Days 15-19 Aug 05, Huntsville, AL. <a href="http://optics.nasa.gov/tech_days_2005/index.html">http://optics.nasa.gov/tech_days_2005/index.html</a> GOVERNMENT PURPOSE RIGHTS					
<b>14. ABSTRACT</b> A series of lightweighted CVC SiC mirror structures were evaluated for characteristic frequency. The lightest structure considered (areal density = 4.7 kg/m <sup>2</sup> ) had a first harmonic mode > 3500 Hz. Under a thermal load of 100 W m <sup>-2</sup> , the surface distortion was less than 1/10.					
<b>15. SUBJECT TERMS</b>					
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			Ryan Conk
			SAR	8	<b>19b. TELEPHONE NUMBER (include area code)</b> (505) 853-8217

**CVC SiC Mirrors for High Energy Laser  
Applications**

*Trex Enterprises Corporation  
Lihue, Hawaii*

Space and Missile Defense Conference and Exhibition

August 16-18, 2005

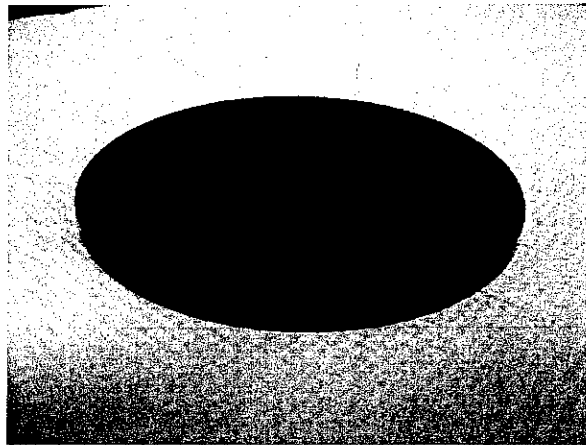
Huntsville, Alabama

**CLEARED  
FOR PUBLIC RELEASE**  
*AFRL/DEO-PA  
29 JUL 05*

In another SBIR effort, we were interested in the mechanical and thermal stability of mirrors fabricated from CVC SiC.

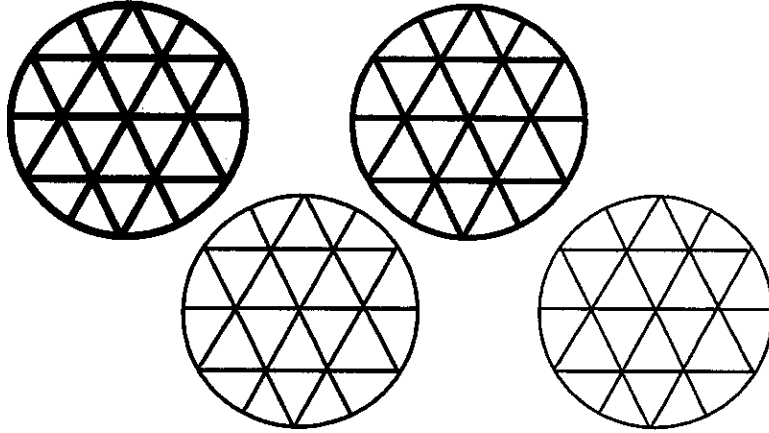
US Air Force  
AF04-008 SBIR Phase I

This was funded under Air Force SBIR topic AF04-008.



$d = 15.2 \text{ cm}$   $t = 0.6 \text{ cm}$  Areal Density  $8.74 \text{ kg/m}^2$   
Element aspect ratios 18.8, 15.7

In order to reduce areal density, CVC SiC material can be removed via machining, even if for designs where the facesheet and rib walls are very thin. **This figure** shows a 15.2 cm diameter, 0.60 cm thick CVC SiC disc that has had material removed via machining. The facesheet and rib thickness are 0.15 cm. The 12 full triangular rib elements have effective aspect ratios of 19. The partial triangle elements at the perimeter have aspect ratios of 16. The total mass and areal density are 0.163 kg and  $8.98 \text{ kg/m}^2$ , respectively. The machining of the rib backing structure removed approximately 53% of the total mass.

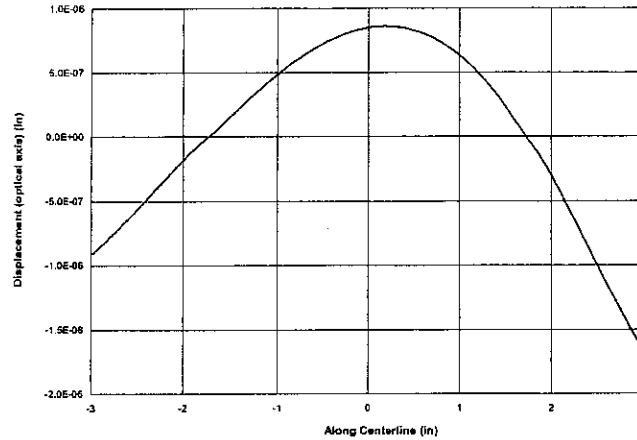


Component Thickness (mm)							
Diameter	Height	Rib	Perimeter Ring	Face	Mass (kg)	Areal Density (kg/m <sup>2</sup> )	First Mode (Hz)
152	7.62	6	6	6	0.613	33.8	6740
152	7.62	4	4	4	0.408	22.5	5760
152	7.62	2	2	2	0.203	11.2	4970
152	7.62	0.5	1	1	0.086	4.7	3590

The basic lightweight mirror structure was evaluated for fundamental and higher harmonic frequencies using finite element analysis. This task was executed by ATA Engineering. For the frequency analysis, four different structures were considered. All had a diameter of 152 mm and thickness of 7.62 mm. What was varied were the thicknesses of the various components, the facesheet, the ribs, and the perimeter ring.

You can see that as the component thickness is reduced, the areal density also decreases, as does the first harmonic mode of the part.

Finite Element Analysis: Steady State Thermal Response with  $100 \text{ W m}^{-2}$  Heat Load Off-Center.



ATA Engineering also considered the situation where the mirror was exposed to a heat source. This plot shows the mirror distortion across a trace through the center of the structure. The heat load was  $100 \text{ W/m}^2$ . The asymmetric curve is due to the incident light impinging on the mirror somewhat off center. In any case the total distortion was  $62.4 \text{ nm P-V}$ , or less than  $1/10 \lambda$  for a He-Ne based metrology.

## Conclusions

1. A series of lightweighted CVC SiC mirror structures were evaluated for characteristic frequency. The lightest structure considered (areal density =  $4.7 \text{ kg/m}^2$ ) had a first harmonic mode  $> 3500 \text{ Hz}$ .
2. Under a thermal load of  $100 \text{ W m}^{-2}$ , the surface distortion was less than  $1/10 \lambda$ .

Above points will be paraphrased in the presentation.