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NOVEL COST-EFFECTIVE PROCESS FOR THE
REPLICATION OF HYBRID DIFFRACTIVE/
REFRACTIVE OPTICAL ELEMENTS IN SILICA
GLASS

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Instrumentation and Controls Division

**NOVEL COST-EFFECTIVE PROCESS FOR THE REPLICATION OF HYBRID
DIFFRACTIVE/REFRACTIVE OPTICAL ELEMENTS IN SILICA GLASS**

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ABSTRACT

This CRADA between Martin Marietta Energy Systems, Inc. (Contractor) and GELTECH, Inc. (Participant) has demonstrated the feasibility of producing hybrid diffractive/refractive optics by a replication process which lends itself to high-volume, low-cost production. The program has built upon unique capabilities of the Contractor and the Participant to achieve this demonstration. The Contractor has extensive experience and unique capabilities in the technology of single point diamond turning for optical components. The Participant has achieved unique success in the development of manufacturing processes for high-quality silica optical components using sol-gel technology. The merging of these two leading technologies has provided a synergism resulting in the demonstration of a manufacturing technology for cost-effective, high-volume production of silica glass precision hybrid optical components.

Hybrid optical components are systems that integrate diffractive optical surfaces into lenses, resulting in designs that minimize the aberrations that degrade image quality without the need for additional glass elements. This reduces the cost, weight, and complexity of the system, while improving the overall optical efficiency. Previous applications of hybrid optical components have been primarily for infra-red applications, where diamond-turned germanium or silicon optics have been used. Hybrid optics for use in the visible have been limited to laboratory curiosities that were directly turned into plastic substrates. Through this CRADA we have achieved a manufacturing process for producing high quality silica glass hybrid lenses in an way that lends itself to mass production.

Applications of hybrid optical components can be found in both federal and private sector venues. Federal applications include rifle scopes, heads-up displays, surveillance cameras, and waste remediation efforts. Benefits to the private sector can be realized in applications such as photographic and video cameras, medical imaging systems, optical storage disk drives, optical communications, and many reproductive imaging systems. These benefits to the private sector can only be realized through the development of cost-effective manufacturing technologies such as the one developed in this CRADA.

1. OBJECTIVES OF THE CRADA

The objectives of this CRADA were to: develop methods for designing hybrid optics, convert the designs into tool paths for single point diamond turning of master mold surfaces, diamond turn the mold pins, cast plastic molds from the diamond turned master surfaces, and produce sol-gel silica hybrid lenses from the plastic molds. The performance of the final optics obtained from these processes was characterized and compared to an industrially comparable multi-element lens.

2. ASSURANCE THAT THE CRADA OBJECTIVES HAVE BEEN MET

All of the tasks described under the Scope of Work in the original Statement of Work (SOW) have been performed. The evaluation optic, a hybrid diffractive/refractive lens was designed and its performance modeled. The master optical surfaces for this lens were diamond turned into a nickel plated stainless steel mold pin (supplied by the participant) for use in the injection molding process. The Participant then fabricated the injection molded plastic mold in two halves. The Participant then completed the manufacturing process by casting and processing the sol-gel silica lens. Finally the evaluation optic was tested for its performance and the results compiled in a conference paper. These activities completed the Tasks 1 through 5 as outlined in the SOW.

3. BENEFITS TO DOE AND OAK RIDGE NATIONAL LABORATORY

DOE has benefitted from this CRADA by furthering the development of a technology that will enable smaller, lighter high-performance optical systems to be constructed through a revolutionary manufacturing process. The resulting benefits to DOE will accrue in programs requiring the use of compact, lightweight, sophisticated optical systems. Within ORNL, this CRADA has enabled the evaluation of new processes and tools for diamond turning diffractive optical structures and similar complex structures. In addition, the program has provided international visibility to the DOE/ORNL/Geltech effort in the form of a highlight article in a recognized optics publication, "Laser Focus World" (see Appendix A).

4. TECHNICAL DISCUSSION OF WORK ACCOMPLISHED

Closely following the task statements in the SOW, the CRADA was executed in a manner that culminated in a very complete conference publication (Appendix B, "Hybrid optics for the visible produced by bulk casting of sol-gel glass using diamond-turned molds"). This document describes in detail the objectives, design considerations, manufacturing issues and final performance evaluation of the prototype lens. This document was presented at the Society of Photo-Optical Instrumentation Engineers

(SPIE) conference on Optical Manufacturing and Testing, July 1995, San Diego, California, and appears in the proceedings of that conference.

5. INTELLECTUAL PROPERTY CONSIDERATIONS

No intellectual property was developed or disclosed in the course of this CRADA.

6. ASSESSMENT OF COMMERCIALIZATION POSSIBILITIES

The Participant is deeply committed to commercialization of this process and has entered into a Phase II STTR to ensure that it will occur. Applications include opportunities as diverse as rifle scopes and endoscopes. Indeed the potential for mass-produced hybrid optics in silica glass are limitless. They will replace alternative optical elements that require multiple optical surfaces and different glass types. The performance advantages and compactness make their application very compelling.

7. PLANS FOR FUTURE COLLABORATION

The Participant has already successfully gained acceptance of its Phase II STTR proposal to continue this work. That work will include an expansion of the scope of the optics produced. In addition to sol-gel silica, press-molded glass and injection molded plastic hybrid lenses will be produced. In this Phase II STTR, ORNL will share in the activities of the larger (0.5 M\$) program.

8. CONCLUSIONS

This has been a very successful CRADA. It exemplifies the type of cooperative interaction between a national laboratory and an industrial partner that can lead to significant technical and commercial achievements that have technical and economic benefits well beyond those enjoyed by the CRADA partners. Further, this was the first DOD STTR to include a DOE laboratory as a major contributor and the outstanding results achieved speak well for the collaboration.

Appendix A

Hybrid Lenses Offer Two-Color Correction
Laser Focus World, October 1995

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Appendix B

Hybrid Optics For The Visible Produced By Bulk Casting Of Sol-Gel Glass Using Diamond-Turned Molds

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