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Evaluation of Aerogel Clad Optical Fibers Final Report CRADA No. TSB-1448-97

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Evaluation of Aerogel Clad Optical Fibers

Project Accomplishments Summary
CRADA No. TSB-1448-97

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A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Ocellus, Inc.

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B. Background

Fiber-optic based sensors will be needed for *in situ* monitoring of degradation products in various components of nuclear weapons. These sensors typically consist of a transducer located at the measurement site whose optical properties are modulated by interaction with the targeted degradation product. The interrogating light source and the detector for determining sensor response are located remotely. These two subsystems are connected by fiber optic cables.

LLNL has developed a new technology, aerogel clad optical fibers, that have the advantage of accepting incident rays over a much wider angular range than normal glass clad fibers. These fibers are also capable of transmitting light more efficiently. These advantages can lead to a factor of 2-4 improvement in sensitivity and detection limit.

Ocellus, Inc. is a California company located in the San Francisco Bay Area (Alameda, CA). The technology focus of the company is the development, manufacture, and sales of new light-weight forms of silica and carbon (including aerogels), and novel products containing these materials. The technical staff includes chemists, engineers, and physicists who have experience in sol-gel and aerogel chemistry, processing, and characterization. A goal of their in-house research program is to develop specialty optical devices that contain aerogel components. Although Ocellus has considerable expertise in sol-gel and aerogel chemistry, they do not have expertise in optical sources, photon transport, or photon detection nor do they have resources to pursue these activities.

C. Description

A study to determine how practical these cables are when implemented as part of a fiber-optic sensing system. Issues to be addressed are effectiveness as a sensor component compared to glass-clad fibers, durability, chemical and physical stability, ease of manufacture, and production cost. This work was done in conjunction with other projects that seek to use LLNL developed aerogels as a high-surface area compact sensor substrate.

This CRADA consisted of two parts. Part I was composed of spectroscopic measurements to determine the optical characteristics (light throughput, numerical aperture, dispersion of transmitted light, etc.) of an aerogel-clad optical fiber. Part II consisted of a preliminary feasibility analysis of fluorescence collection and transmission an aerogel-clad fiber optic based on the results from Part I. This analysis will address issues of sensitivity, practical dynamic range, linearity, etc.

The work consisted of imbedding fiber-optics within an aerogel cladding. This was accomplished by fabricating a fixture that retained a fiber in a cylindrical enclosure that could be filled with a liquid monomer. After gellation of this mixture, the fixture and fiber were subjected to high temperature supercritical processing conditions to remove the solvent without collapse of the gel structure to produce an aerogel clad fiber-optic. The resultant fiber was subjected to testing to determine the characteristics of light transmission. Although the light throughput, increase in numerical aperture, and dispersion of transmitted light was observed as anticipated, the coupling efficiency of the light source to the test piece was problematic. Although numerous schemes to systematically couple the source for measurements were tried, the efforts were not reproducible. The engineering remedies to adequately address these concerns were beyond the scope of this work.

D. Expected Economic Impact

Ocellus is presently investigating technology in fiber optic sensor applications where improved light collection and transmission efficiency may result in improvements in sensitivity, detection limits, and other key parameters of fiber optic sensors. In addition they are interested in applying this technology to develop fiber-optic surgical illuminators capable of large area illumination, especially for eye surgeries. These development efforts are in their infancy, no products have yet resulted from this work.

If this research eventually results in optical sensors of increased sensitivity, the benefits to the U.S. economy would be manifested in new markets and related jobs. The availability of such devices would increase OCELLUS' worldwide sales of optical devices, and also provide the basis for an entire new product line.

E. Benefits to DOE

Benefits are to the National Ignition Facility, the nuclear weapons complex factory of the future, and the Department of Energy's Enhanced Surveillance Program (ESP).

The work associated with this CRADA enhances the core competencies in the areas of sol-gel technology, optical spectrometry, fiber optics, opto-electronics, chemical microsensors, optical detector technology, micro-lens technology, and solid-state laser technology, all of which are relevant to NIF and the Enhanced Surveillance Program. Innovations in the area of opto-chemical sensors are particularly important because they leverage LLNL capabilities that apply to the Enhanced Surveillance Program.

This CRADA proposes to develop chemical sensors that are interrogated via a lens coupled system with the chemical sensor package. This has relevance to the DOE Defense Programs' initiative for in-situ monitoring of internal nuclear weapons components and in particular the remote monitoring of the chemical integrity of key components. Optical-chemical lens coupled sensors would also have high value to the DOE Enhanced Surveillance Program because of their minimally intrusive character which allows for sensing through fiber optics thus eliminating the need for penetrating electrical cables.

Chemical sensors will also find wide applicability in Advanced Manufacturing which is a principal part of the DOE mission. These chemical sensors could be used in process control of HE production, for sensing specific organic chemicals, and for quantifying waste stream constituents.

Innovations in opto-chemical sensors will also have relevance to the nuclear weapons complex in the areas of environmental monitoring and monitoring effluents. Opto-chemical sensors may also find applications in the detection of CW/BW agents

F. Industry Area

Fiber-optic based sensors using new light weight forms of silica and carbon (including aerogels), and novel products containing these materials.

G. Project Status

The project was completed in December 1998.

H. LLNL Point of Contact for Project Information

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I. Company Size and Point(s) of Contact

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J. Project Examples

None.

K. Subject Inventions

This small value contractual mechanism did not anticipate any generation of Intellectual Property (IP) including subject inventions. The LLNL contributors and the company participants both indicate that no new intellectual property was generated.

L. Release of Information

I certify that all information contained in this report is accurate and releasable to the best of my knowledge.

for Kathy Kaufman — 10/26/00

Karena McKinley, Director
Industrial Partnerships
and Commercialization

Date

RELEASE OF INFORMATION

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

Michael W. Droege — 10-13-2000

Michael W. Droege, Technical Contact
Ocellus, Inc.

Date