Title of Investigation:

Characterization of the Semiconductor Fiber Light Amplifier (SCFLA)

Principal Investigator:

Dr. Tracee L. Jamison, Code 562

External Collaborators:

Dr. Philipp Kornreich (Syracuse University)

Initiation Year:

FY 2004

Aggregate Amount of Funding Authorized in FY 2004 and Earlier Years:

$0

FY 2004 Authorized Funding:

$40,000

Actual or Expected Expenditure of FY 2004 Funding:

Contracts: $10,000 for materials and equipment;
Grants: $30,000 to Dr. Philipp Kornreich (Syracuse University)

Status of Investigation at End of FY 2004:

The SCFLA test set-up(s) and lab-view programming platforms have been developed. Fiber absorption measurements have been performed.

Expected Completion Date:

July 2005

Purpose of Investigation:

Dr. Philipp Kornreich invented the Semiconductor Cylinder Fiber Light Amplifier (SCFLA) at Syracuse University (see Figure 1). The SCFLA possesses attributes that make it superior to currently used erbium-doped fiber amplifier (EDFA) technology for making lasers (see Table 1). EDFA technology, for example, limits lasers because of its narrow bandwidth. However, the SCFLA produces a wide-bandwidth fiber laser that scientists could use for surface topography measurements. In addition, by changing the semiconductor material between the core and cladding of this device, more wavelengths could be used, allowing for more flexibility in science applications. (The core is made of cylindrical glass with a higher index of refraction than the cladding, which surrounds the core and is made of glass. It is like an extension cord. Inside the cord is the wire, also known as cladding, and surrounding the wire is the rubber). In addition, the SCFLA's compact design and ease of integration into fiber networks make it ideal for spaceflight missions. However, more extensive testing needs to be performed before qualifying the device for spaceflight. In this investigation, we propose to test and characterize the SCFLA device in the Code 562 Photonics Laboratory and Syracuse University.

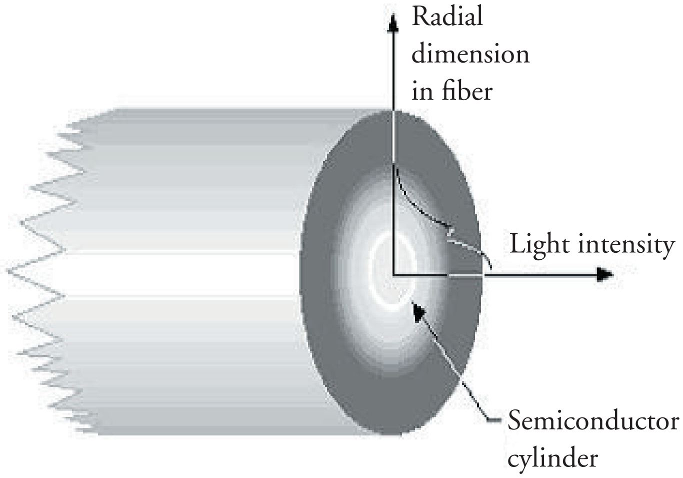

Figure 1. Semiconductor Cylinder Fiber Light Amplifier

FY 2004 Accomplishments:

The objective of this proposal is to characterize the SCFLA for performance in four areas: gain, Amplified Stimulated Emission (ASE) noise levels, saturation level, and pump light response time. To determine the gain at each wavelength between 1300-2200 nm, the operational region of the device, we used an 832-nm laser in the test set-up as the pumping source for the SCFLA device. We then plan to use different pumping configurations to determine the ideal arrangement for optimum gain. High-power light- emitting diodes will eventually be used as the pumping source. Following complete characterization, we plan to design the SCFLA packaging. In the future, we plan to fabricate the SCFLA into a wide-bandwidth Semiconductor Cylinder Fiber Laser.

We have created six fiber preforms with a thin-film semiconductor material (Cd3P2) between the fiber preform's core and cladding. (To make fibers, a 1-mm cylindrical solid rod is inserted inside a tube. The glass(es) are melted together and the resulting piece is then inserted into a larger tube. This process is repeated until the thickness of the structure is 6 mm. This 6-μm cylindrical glass structure is called a fiber preform. The 6-mm thick fiber preform is then heated inside an oven and pulled into 125-μm thick optical fibers. The original glass rod serves as the core of the fiber and the tubes are the cladding of the fiber.) We have pulled one preform into 125 μm of semiconductor cylinder fiber light amplifier (SCFLA). We have optimized the experimental set-up by using more optics to align the cores of the SCFLA fiber to prevent the light guiding in the cladding of the SCFLA from reaching the detector and distorting the results. We have performed transmission tests through a 2-mm piece of SCFLA fiber to verify the absorption spectra.

Table 1. Comparison of Erbium-Doped Fiber Amplifiers (EDFA) and Semiconductor Cylinder Fiber Light Amplifiers (SCFLA)

	EDFA	SCFLA
Gain	1dB/m	3dB/mm
Length of Fiber	20-40m	2-4mm
Bandwidth	30nm	900nm
ASE Noise	40dBm	75dBm
Gain Flattening Required	Gain flattening circuit	None Required
Couplers Required	Input/Output Couplers Required	None required
Pump Source	Single Mode Laser	LED

Publications and Conference Presentations:

Presented at Photonics North on September 24, 2004 in Ottawa, Canada: "Wide Band Gain and Amplified Stimulated Emission Measurements in Cd_3P_2 Cylinder Fiber," by John F. Dove (deceased), Rome, New York; Allen Chi-Luen Wang, SDO Corporation, 42986 Osgood Road, Fremont, California; Tracee L. Jamison, NASA Goddard Space Flight Center, Greenbelt, Maryland; Ramesh Narayanan, Akshob Bangle, Zheng-Xuan Lai, James Flattery, Douglas Keller and Philip Kornreich, Department of Electrical Engineering and Computer Science, Syracuse University, Syracuse, New York.

Tracee L. Jamison, Philip Kornreich, and Chung Yu, "Novel Inter-core-Cladding Lithium Niobate Thin-Film-Coated Fiber Modulator/Sensor," SPIE, International Society of Optical Engineering, 5347, 118 (2004).

Patents:

The Semiconductor Fiber Light Amplifier (SCFLA) by Dr. Philipp Kornreich (Syracuse University), John Dove (Dove Photonics), James Flattery (Syracuse University) and Douglas Keller (Syracuse University), patent number pending.

The Lithium Niobate Cylinder (LNC) Fiber by Drs. Tracee Jamison (NASA Goddard Space Flight Center), Philipp Kornreich (Syracuse University), and Douglas Keller (Syracuse University), patent number pending.

Planned Future Work:

Our future work will extend to building a fiber laser using the SCFLA.

Summary:

Syracuse University is the only university that possesses a patented low-temperature technique for fabricating thin-film semiconductor material between the core and cladding of an optical fiber. Dr. Tracee Jamison of the Goddard Space Flight Center invented at Syracuse University a methodology for depositing lithium niobate sol gel material between the core and cladding of an optical fiber. Table 1 illustrates the SCFLA's innovative features.

The SCFLA can be used in place of the EDFA to enhance fiber laser designs. The SCFLA device has a huge potential of being integrated into instruments where wide bandwidth is necessary, particularly in the area of atmospheric and surface topographical measurements. The use of the SCFLA in fiber laser designs will permit tuning over a wider bandwidth. Scientists will be able to take advantage of more wavelengths with increased bandwidth. Different semiconductor materials can be used at the core/cladding interface to use different science wavelengths.

The main criterion for success would be verifying the high gain of the device over a large bandwidth. Our main challenge has been in the acquisition of glass at melting temperatures comparable to our needs. Because our fabrication process requires lower temperature glass than the current industry standard, obtaining high-quality glass continues to be a challenge. Obtaining a uniform coating between the core and cladding of the fiber is also an issue and has a lot to do with the non-uniformity of the deposition and fiber-pulling processes. We have encountered challenges in cleaving a 2-mm piece of fiber. Attaching a regular fiber to the SCFLA fiber is like aligning two tubes together with very small openings. If the two tubes are not aligned correctly, light will not go into the second tube. This has been difficult because the core of the laboratory-made SCFLA fiber is not always centered.