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This grant was used to buy a tunable continuous wave laser source and beam diagnostic package that is now being used to characterize the spectral response of photorefractive materials and photonic bandgap structures. Devices made of such structures that are incorporated into our unique fibers (made in our laboratory) are also now being characterized. Our laboratory is active in DOD and private-sector-sponsored interdisciplinary research that spans materials processing, characterization, and device demonstration with particular emphasis on all-optical devices such as optical limiters, which are based on photonic fibers and photorefractive fibers. The experiments will aid in understanding the physical properties of matrials, how they are affected by processing, and how the operation of devices is influenced by processing and material composition. Furthermore, this equipment is being used to enhance the learning experience of the half dozen undergraduate students from physics, engineering and materials science along with several graduate students and post docs who routinely use this equipment in their research.

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Final Report to AFOSR
Characterization of Photorefractive and Photonic Bandgap Composite Fibers

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Grant Number: F49620-01-1-0267

Contents

1 Summary

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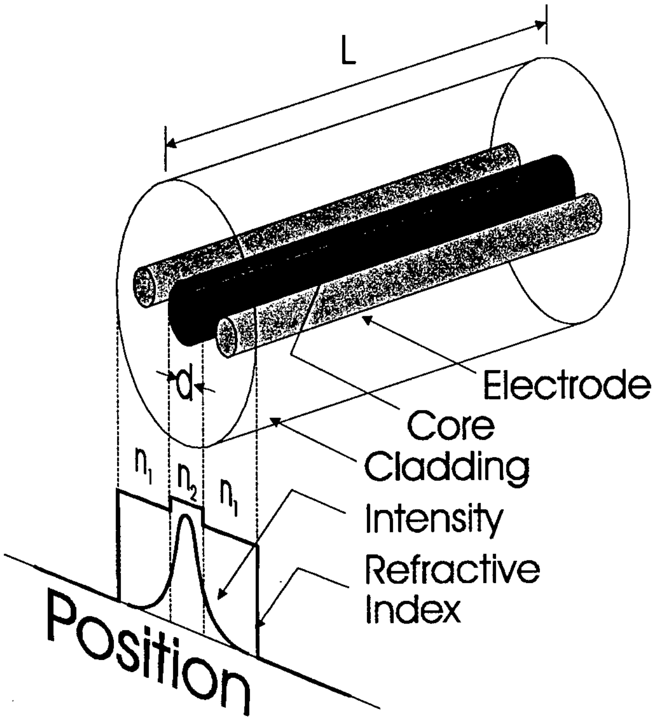

Figure 1: Cross-sectional view of a single-mode polymer optical fiber with embedded electrodes. The size of the core and electrodes has been exaggerated in this illustration.

2 Research Areas

2.1 Electrooptic Fibers

Figure 1 shows a schematic representation of the cross-section of a single mode electro-optic fiber that we were making in our laboratory at the time the original proposal was written. The core consists of a dye-doped polymer which gives rise to the elevated refractive index and is the source of the nonlinearity. The indium electrodes are compatible with the low processing temperature which is required when using molecular dopants. The electrodes can be used both for poling the material and for electrooptic modulation.

2.2 Photoisomerization

We made the major discovery that using the photoisomerization mechanism in a polymer optical fiber core, optical limiting can be observed without the need for electrodes. (This work is funded by AFOSR.) In the photoisomerization mechanism, the refractive index of the material decreases as the intensity increase. To implement optical limiting in a polymer optical fiber, we have developed a new technique that we call mode-cut optical limiting (M-COL). It works as follows. As the refractive index of the multimode core decreases, the number of waveguide modes that are supported decreases. As such, some of the modes are removed and the intensity that is transmitted down the guide saturates. The modes that are cut out of the wave guide are launched into the cladding. To prevent these radiated modes from making it to the end face of the fiber, the cladding is painted black to absorb

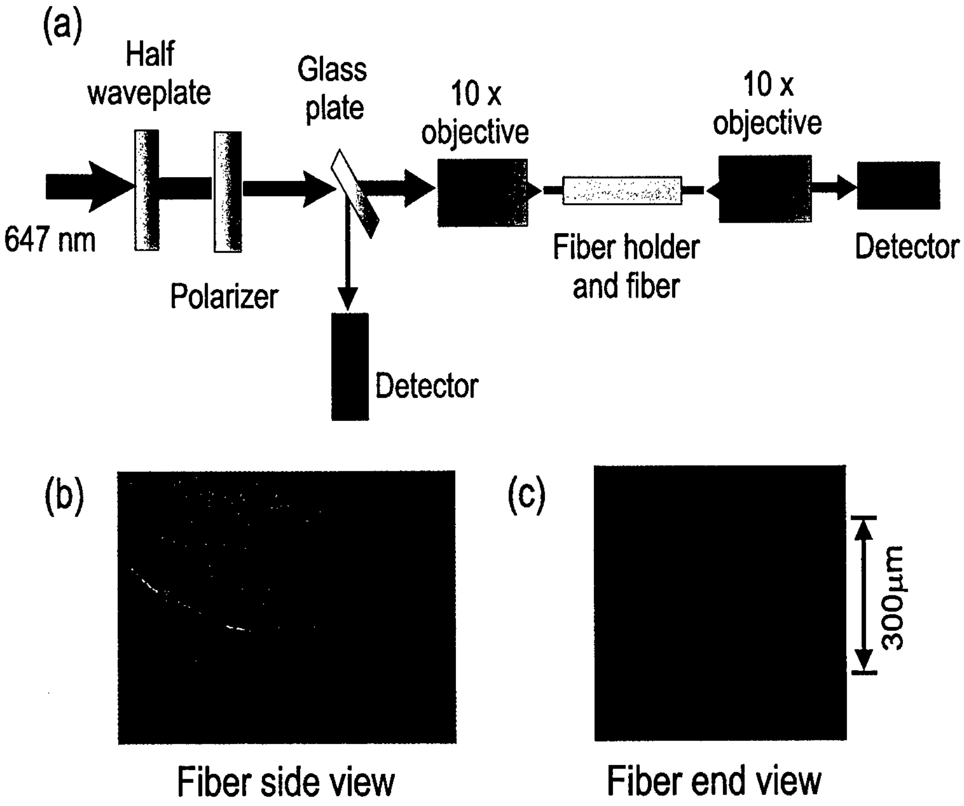

Figure 2: a) Experimental setup for mode cut optical limiting; (b) a fiber with the cladded painted black; and (c) a photo of the waveguide mode in a 50μm core fiber.

the light. The new equipment purchased under this grant has been used to perform these measurements.

Figure 2a shows the experimental setup. The incident intensity is measured by reflecting a small amount of the light from the laser into a detector. The transmitted intensity is then measured as a function of the incident intensity. Figure 2b shows the fiber that was used for these experiments. The cladding is painted black. 2c shows the light intensity at the output of the fiber 300μm diameter cladding and 50μm diameter core.

Figure 3 shows the transmitted power through the core as a function of incident power. Above about $1\text{kW}/cm^2$, the output power begins to saturate. While these results are for a continuous wave (CW) incident beam, we have seen that the onset of limiting occurs at about 35ms after the laser is turned on and saturates after about 350ms. Work to identify new materials and to make the core smaller (i.e. stronger mode cut-off at lower intensities) is in progress.

2.3 Photonic Fibers

We have been making a variety of photonic crystal structures in polymer optical fiber and dye-doped polymer optical fiber. (This work is supported by ARO.) These include the so-called "holey fibers," which prorogate light down the length of the fiber, as well as photonic crystal structures, which are illuminated transverse to the fiber axis. Figure 4a shows a

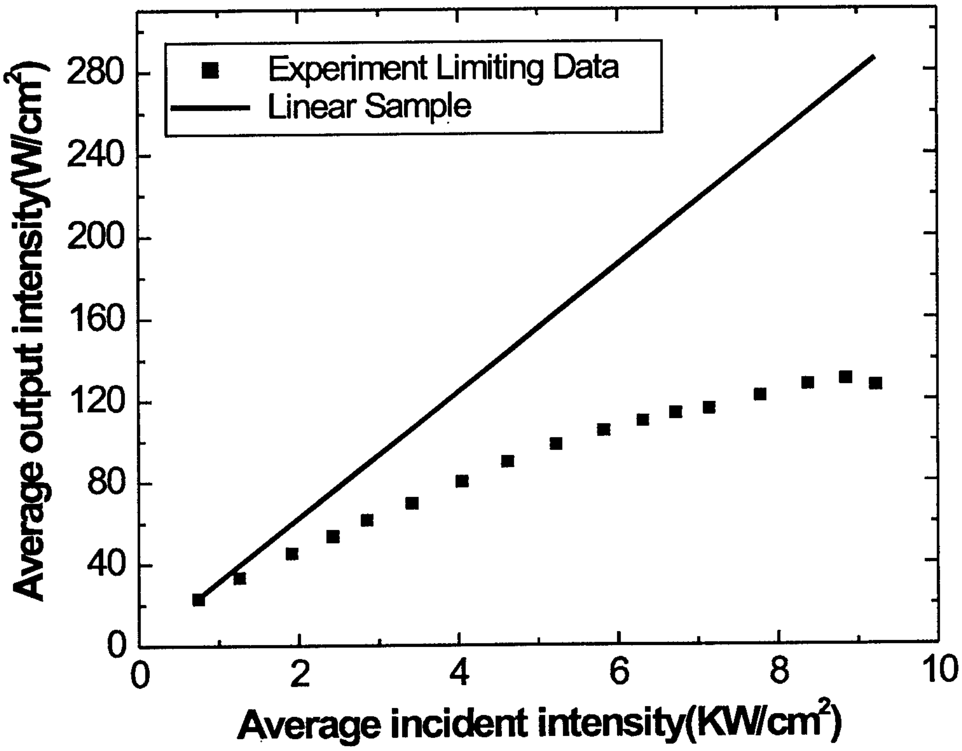

Figure 3: Mode cut optical limiting in a polymer optical fiber.

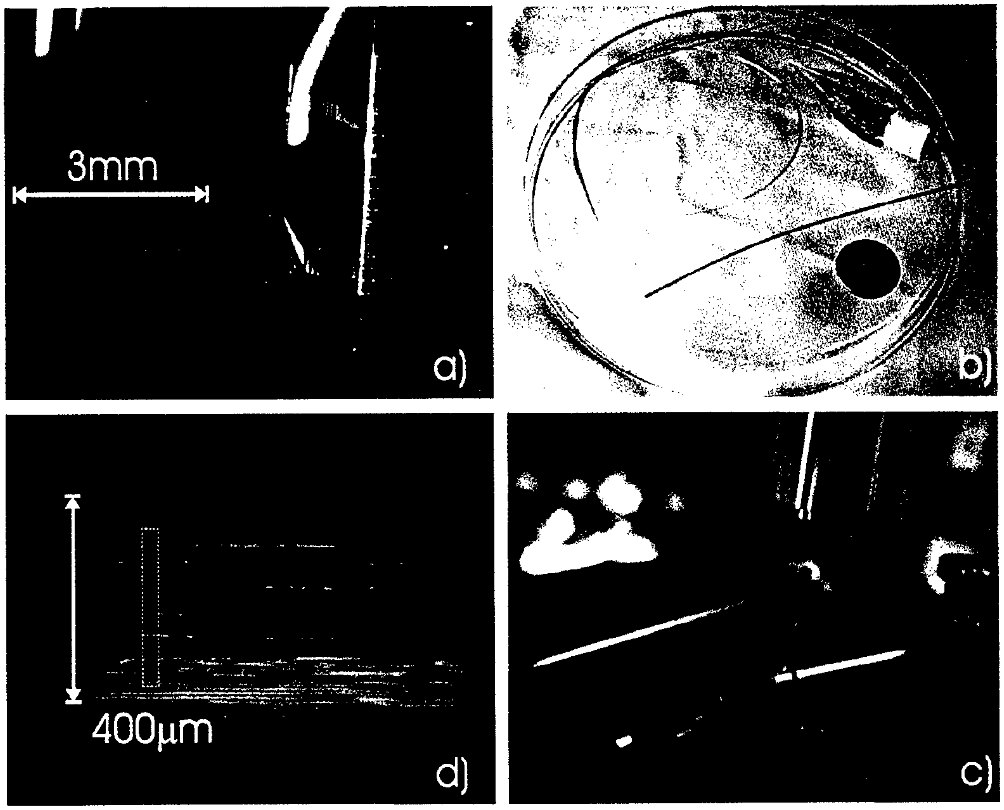

Figure 4: Mode cut optical limiting in a polymer optical fiber.

preform (end view and side view) of DR1 dye-doped polymer with an array of indium electrodes. The dye is nonlinear through the photoisomerization mechanism and the metal array provides the filtering. Since the refractive index depends on the intensity, the filtering properties depend on the intensity. Figure 4b shows an actual fiber that was pulled from such a preform. Figure 4c shows the fiber end being observed with a microscope and Figure 4d shows a side view of the fiber under a microscope. Work is in progress to improve the fiber quality. The equipment purchased by the DURIP award is being used to characterize these structure.

2.4 Other projects

Many other experiments are using the equipment purchased with this grant. They include z-scan and t-scan of dye-doped films, time resolved self-defocusing, photochromism, photorefraction, and others. More than a dozen publications will result from these experiments in 2002 alone.

3 Purchased Equipment

Purchased Equipment Items:

Kuzyk Equipment Purchases AFOSR #F496200110267

INVENTORY	ROOM	LOCATION	PO NUMBE	PURCHASE	PURCHASE C	ACCOUNT	LOCAL DESC	MODEL NUM	SERIAL NUM	MANUFACTURER
374800	0746A	KUZYK	329476	6/27/01	3,869.43	24640329	GATEWAY E4600XL COMPUTER	E4600XL	0023808309	GATEWAY
375945	0724	KUZYK	332710	8/15/01	2,473.72	24640329	2000 FIBER OPTIC SPECTROMETER	USB2000	USB2E1695	OCEAN OPTICS
376901	0726	KUZYK	335250	9/25/01	3,748.00	24640329	DUAL FIBEROPTIC SPECTROMETER,S2000	SD2000	D2J1195	OCEAN OPTICS
377003	0726	KUZYK	327526	10/3/01	117,926.67	24640329	VERDI 8 WATT LASER SYSTEM	VERDI-8W	V8-A1106	VERDI
377225	0726	KUZYK	335897	10/15/01	3,517.44	24640329	PC-3 ULTRA UV SPOT CURING UNIT	PC-3 ULTRA	97410226	ELLSWORTH
379411	0724	KUZYK	334163	11/29/01	2,904.82	24640329	SOLEIL-BABINET COMPENSATOR	PORT # SB-10	21446	OPTICS FOR RESEARCH
373983	0724	KUZYK	324193	5/21/01	3,846.70	24640329	BEAMSTAR V CCD LASER BEAM PROFILING SYST	185001	99969	OPHIR OPTRONICS
374081	0724	KUZYK	321592	5/30/01	6,381.67	24640329	COHERENT WAVEMASTER WAVELENGTH METER	CAT.NO.33-26-2650	W0169	COHERENT
					144,668.45					