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Transmission properties of nonlinear multimode waveguide arrays

Description

Multimode capillary waveguide arrays containing reverse-saturable absorbers exhibit an enhancement of the nonlinear response. Experimental data are modeled by the effect of partial mode filling, influenced by fill fraction and capillary diameter.

Disciplines

Physical Sciences and Mathematics

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Transmission properties of nonlinear multimode waveguide arrays

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Abstract: Multimode capillary waveguide arrays containing reverse-saturable absorbers exhibit an enhancement of the nonlinear response. Experimental data are modeled by the effect of partial mode filling, influenced by fill fraction and capillary diameter.
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Nonlinear multimode waveguide arrays have important applications in areas such as optical networks and imaging systems.[1] Here we report on the nonlinear transmission properties of multimode capillary waveguide arrays containing reverse-saturable absorbers. These arrays were designed and fabricated at the Naval Research Laboratory to have large packing fractions and high overall transmissions. Single such waveguides have been observed to exhibit an enhanced nonlinear response because of the extended interaction distance and because the light does not uniformly fill the waveguide, but is distributed among a few of the allowed modes.[2] We report a similar enhancement in nonlinear multimode waveguide arrays.

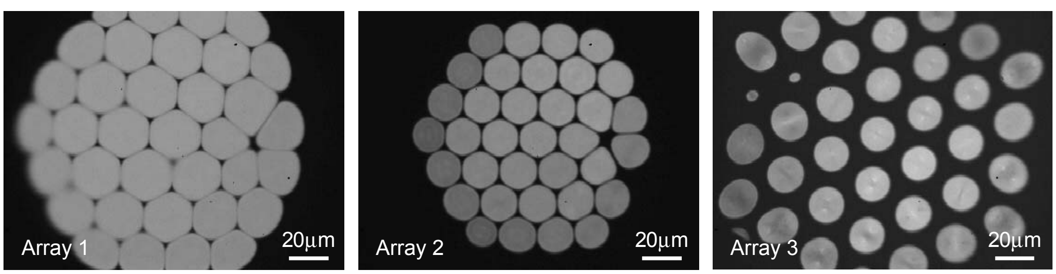

Fig 1. White light images of capillary arrays.

Capillary waveguide arrays were fabricated using the standard stack and draw technique in which capillaries drawn from silica GE214 tubing are hand stacked to form a close-packed array. The capillary diameter, d, the pitch, Λ, and the diameter to pitch ratio, d/Λ, for three capillary arrays tested are summarized in Table 1.

Table 1. Dimensions of Capillary Arrays

	d (μm)	Λ (μm)	d/Λ
Array 1	24	24	~1.0
Array 2	17	18	0.94
Array 3	17	25	0.68

The capillary arrays were filled with a 0.325 mM dioctyl phthalate solution of bis[tri-(n-hexyl)siloxy] silicon naphthalocyanine (SiNc), a well-known reverse-saturable absorber. White light images of the three filled arrays are shown in Figure 1. Typical sample lengths were 1.8 cm with linear transmissions of 45% at 532 nm.

The transmission characteristics of the center capillary were measured as a function of incident energy using 7 ns pulses at 532 nm. For each array, the laser was focused onto the center capillary and the transmission of the center capillary was measured.

Figure 2 shows the relative transmission of the center capillary. Data is plotted as a function of energy coupled into the entire array because some light was coupled into other capillaries of the array. In each array, the observed energy distribution at the exit of the central capillary was confined to the center of the capillary. The experimental data was compared with the transmission calculated by numerical integration of a five-level sequential absorption rate equation model for SiNc that is known to give a good fit for free-space, nonlinear transmission studies.[2]

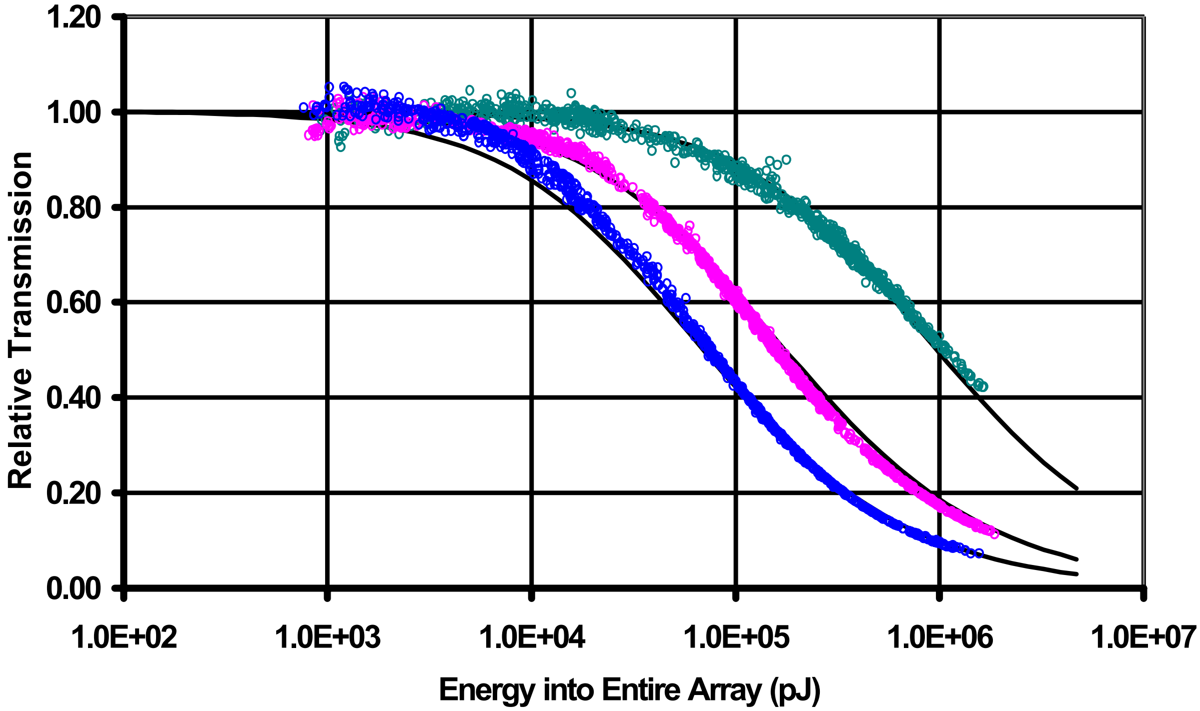

Fig. 2. Center capillary transmission for SiNc filled arrays. Green data points – Array 1; Pink data points – Array 2; Blue data points – Array 3. Lines represent theoretical calculations assuming an effective beam diameter within the center capillary of 14μm for Array 1, 10μm for Array 2, and 8μm for Array 3.

In the theoretical calculations, the effective beam diameter for the energy in the center capillary that gave the best fit to the experimental data was 14μm for Array 1, 10μm for Array 2, and 8μm for Array 3. The effective beam diameters that fit the data are qualitatively consistent with the observed diameters and are smaller than the measured core diameters. This is consistent with the previous results on single waveguides where the light is distributed among the allowed modes so that the effective area illuminated within the waveguide is smaller than the actual core area

In summary, the promising optical limiting capabilities of multimode nonlinear waveguide arrays are confirmed. Multimode capillary waveguide arrays containing nonlinear absorbers exhibit an enhancement of the nonlinear response. This is consistent with studies of single waveguides where an enhanced nonlinear response arises both because of an extended interaction distance and because the light does not uniformly fill the waveguide, but is distributed among a relatively few modes. The mode structure should be considered in the design and evaluation of capillary array optical limiters.

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1. I. C. Khoo, A. Diaz, M. V. Wood, and P. H. Chen, "Passive optical limiting of picosecond-nonosecond laser pulses using highly nonlinear organic liquid cored fiber array," J. Sel. Top. Quantum Electron., **7**, 760-768 (2001).

2. J. J. Butler, J. J. Wathen, S. R. Flom, R. G. S. Pong, and J. S. Shirk, "Optical limiting properties of nonlinear multimode waveguides," Opt. Lett. **28**, 1689-1691 (2003).