TUJ6 Nonlinear properties of silica for picosecond ultraviolet pulses

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The development of excimer lasers has led to the generation of very high power pulses in the UV. There is a potential for large increases in currently achieved power levels and a great deal of interest in conducting experiments with such ultrahigh power short duration pulses. As at longer wavelengths UV lasers are ultimately power-limited devices, the limit on power being due to optical nonlinear processes occurring in the materials of the laser and experimental arrangement, induced by the beam itself and degrading the quality or reducing the energy of the beam. Measurements of two-photon absorption at 249, 266, and 351 nm have been carried out on several materials, and the nonlinear refractive index has been measured at 351 nm.[1-4] However, there is a need for further evidence to enable a proper design of UV lasers and on assessment of their power-limited performance.

A number of measurements have been carried out to provide quantitative information on the nonlinear properties that affect beam propagation and in particular to identify the dominant property and power limit this imposes on the laser. The two principal materials in UV lasers have been assessed, namely silica and air, and measurements have been made at 249 nm, 268 nm (first Raman Stokes of 249 nm in methane), and 293 nm and using different types of commercially available silica.

Nonlinear absorption, probably two-photon absorption, is the dominant process in silica at 249 nm giving a coefficient $\beta = 0.06$ cm/GW but falls rapidly at longer wavelengths to give $\beta = 0.01$ cm/GW at 293 nm. At longer wavelengths the dominant process changes, and energy is lost, not primarily to absorption but to broadband or so-called continuum generation into a forward cone. Thus at 293 nm this continuum loss is characterized by a coefficient of 0.04 cm/GW. The mechanism for this loss appears to be similar to that of the principal loss mechanism in air. Spectral evidence gives some insight into the initial processes leading to a continuum generation in both cases. A two-component spectrum generated sidebands at close to threshold, these rapidly multiplying into a continuum at higher intensities. This can be interpreted as a four-wave mixing process probably enhanced by a nonzero Raman gain.

Two methods of measurement of the nonlinear refractive index of silica at 249 nm have been used. One is the enhancement of spatial intensity modulation giving a value of $n_2 = 1.3 \times 10^{-13}$ esu. To obtain this result, the theory of small scale self-focusing has been modified by the introduction of a damping term to take account of nonlinear absorption.

The second method employed a white light interferometer to measure time integrated intensity-dependent fringe shifts and yielded a value for n_2 of 2.0×10^{-13} esu. **(Poster paper)**

1. Laser Program Annual Report 1982, LLNL, DCRL-50021-82.
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3. A. J. Taylor, R. B. Gibson, and J. P. Roberts, submitted to Opt. Lett.
4. M. H. R. Hutchinson; private communication.