Broadband Thermal Optical Limiter

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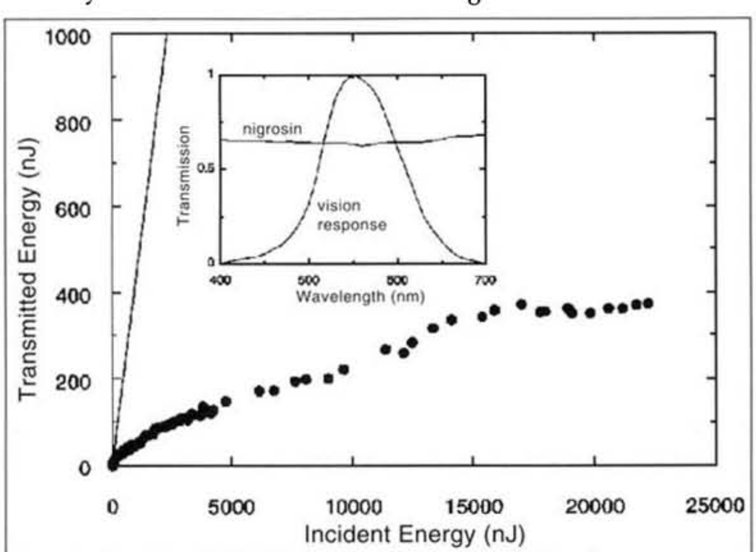
The protection of eyes and sensors from exposure to intense, frequency-agile lasers, using passive optical limiters, is an active area of research. Material and device requirements include high transmission of low intensity light over a broad range of wavelengths, wide field-of-view, a fast yet persistent temporal response, and the ability to avoid or recover from optical damage. Research efforts to optimize the nonlinear optical properties of materials used in optical limiters have resulted in the development of many new and interesting materials.[1]

We recently reported[2] the development of a broadband optical limiter that operates over a wide range of input fluences and provides protection for eyes and sensors for all vision response wavelengths and beyond. This exceptional limiting performance was possible using a well known and ubiquitous nonlinear optical mechanism: thermal defocusing. Historically, the first proposed limiter[3] used such a "thermal blooming" mechanism, but the mechanism received little serious attention for limiting applications because of the common misconception that the response time of the thermal nonlinearity is too slow to be effective against nanosecond duration laser pulses. In fact, we demonstrated that, using f/5 optics in a defocusing geometry, the thermal mechanism is very effective at limiting 6 nsec duration pulses. The experiments were performed using a solution of nigrosin dye dissolved in carbon disulfide. Nigrosin is characterized by an extremely broad and flat absorption over the entire visible and near-infrared spectral regions, is commercially available, and is inexpensive. A plot of the transmission of nigrosin is shown compared to the daylight vision response curve of the eye in the figure shown. Carbon disulfide is a common laboratory solvent with an exceptional thermal figure of merit. F/5 limiting data obtained at 532 nm using 6 nsec duration pulses, for a 25 μm thick sample of nigrosin in CS_2 (T = 47%), are shown. The straight line represents the linear system transmission. The limiting threshold (transmitted energy = half the linear system transmission) occurs at ~40 nJ. The maximum transmitted energy is only 400 nJ for input energies of 20 μJ, representing a net transmission of only 2%.



The solid circles are thermal limiting data obtained for a 25 μm-thick cell of nigrosin/CS_2 (αl = 0.76). The solid line represents the transmission if no limiting were to occur. The inset shows the broadband nature of the nigrosin absorption and compares it with the daylight vision response of the human eye.

The performance of a thermal optical limiter in which the sample heating is enhanced by excited state absorption (ESA) has also been described.[4] The hybrid thermal/ESA limiter demonstrated a lower limiting threshold in addition to higher linear light transmission at 532 nm. A comprehensive experimental and theoretical description of the characteristics of thermal defocusing limiters is also in press.[5]

References

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Photorefractive Polymers Achieve Net Gain, High Diffraction Efficiency and Speed

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Polymers exhibiting the photorefractive (PR) effect have attracted attention lately because this new class of photorefractive materials[1] has the potential for improving the photorefractive figure of merit n^3r/ϵ, where n is the optical refractive index, r is the appropriate electro-optic coefficient, and ϵ is the dc dielectric constant. PR polymers also possess other advantages over inorganic materials, such as compositional flexibility and ease of fabrication. The first PR polymer[2] showed only small diffraction efficiency and slow response, with performance far below commonly investigated inorganic materials. To be considered for practical applications, large improvements in diffraction efficiency, gain, and speed were necessary.