

Optical power limiting with photoinduced anisotropy of azobenzene films

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We study the power-limiting properties of photoanisotropic azobenzene films with low-power lasers. The *trans-cis* photoisomerization and molecular reorientation of azobenzene molecules induced by polarized laser beams result in intensity-dependent anisotropic effects. Consequently, the transmittance of the input beam that passes through the film between two crossed polarizers becomes enhanced at low intensities and clamped at high intensities. The limiting threshold is adjustable by changing the intensity of excitation beam. © 2003 Optical Society of America

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1. Introduction

The rapid development of laser technology has made portable laser systems with high power and energy available. The lasers are widely used for many applications and have greatly advanced scientific research. As they are used everywhere, the odds of a lease beam accidentally hitting a person are increasing. Even low-power lasers can damage human eyes or photosensors. As such, studies of optical power limiting are receiving a lot of interest. Several optical techniques with various materials including inorganic, organic, and biological molecules have been used for such applications. Nonlinear absorption effects including excited-state absorption,¹ reverse saturable absorption,² and multiphoton absorption^{3–5} are widely investigated with high-power pulsed lasers in both theory and experiment. Light scattering is also used to limit the optical power when a strong beam is incident on some materials,^{6,7} and it can enhance the nonlinear absorption. Another important nonlinear optical effect used for the power

limiting is beam diffusing, which originates from the change of spatial distribution of the refractive index and manifests as self-defocusing,⁸ beam fanning (diffusive photovoltaic thermal effects),⁹ and the Kerr effect.¹⁰ The filtering features associated with the holographic technique^{11,12} and photonic bandgap materials^{13,14} are also useful for power-limiting applications. Recently, polarization rotation in resonant Faraday media sandwiched between crossed polarizers¹⁵ and in bacteriorhodopsin materials placed between a pair of parallel polarizers¹⁶ has been studied theoretically and experimentally and could be used for optical limiting applications. These polarization rotation techniques may offer many advantages, such as low-fluence threshold, high-intensity range, and ease of improvement with new materials for practical applications, particularly for protecting human eyes and sensitive optical sensors that can be damaged by even low-power laser beams. In this paper we present a study on photoinduced anisotropic effects of azobenzene polymer films and its application to power limiting. The experimental results we obtained with the crossed polarizer arrangement illustrate clamping close to that of an ideal optical limiter.

2. Experiments

A. Sample Film Preparation and Optical Characteristics

An azobenzene material of 4-dimethylaminoazobenzene is used in our studies. The material possesses optical properties of both *trans-cis* photoisomerization and photoinduced reorientation. The azobenzene molecules are embedded in the poly-

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