Z-Scan Photo-Reflectance Characterization of Resonant Optical Nonlinearities of Surfaces

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Z-scan techniques based upon the distortion of a Gaussian laser beam provide a sensitive means to characterize nonlinear refraction and absorption in a wide variety of materials [1]. In general, Z-scan techniques use the transmittance of a Gaussian laser beam through a finite aperture in the far field to determine the sign and magnitude of nonlinear refraction and absorption. Reflection Z-scan techniques are particularly suited to measure surface nonlinearities of materials with limited transparency [2, 3]. At the same time, photo-reflectance (PR) is a well established technique to study the bandstructure and interfacial electric fields of semiconductors and semiconductor microstructures [4]. In general, PR measures the change in reflectivity of a sample whose surface electric field is modulated by the photo-injection of electron-hole pairs [5]. The physical origin of the PR response is a resonant third order nonlinearity involving one probe photon and two DC field quanta [6]. In this paper, Z-scan techniques are applied to the case of a probe laser beam in a PR setup. In particular, the theory of laser beam propagation as it applies to the probe laser beam in a PR apparatus is described and the use of Z-scan PR to independently characterize resonant nonlinear refraction and absorption in silicon-germanium samples exhibiting large absorption is demonstrated.

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