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Institute of Laser for Postgraduate Studies

Calculations of Nonlinear Refractive Index and Nonlinear Absorption Coefficient for Some Solid Materials

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Abstract

In the present work, the parameters that determine the nonlinear optical properties of materials via Z-scan method, were extensively studied in the frame of its importance and effect. These parameters are classified into three groups; laser parameters, material parameters and geometrical parameters. The laser parameters include wavelength, power density and pulse duration. The material parameters include specific heat, thermal conductivity, mass density and material temperature, while the geometrical parameters are sample length, position of sample during the test besides the lens focusing and detector aperture. In this work we calculated the nonlinear refractive index and nonlinear absorption coefficient for eighteen optical materials also explained how one can calculate these factors to other materials. From this work we found that a 1% increase in laser power density or sample length at constant anther parameter lead to increase the difference in normalized transmittance from peak to valley (ΔT_{pv}) by 1%. An increase of laser wavelength leads to decrease the ΔT_{pv}. The total refractive index also increases with the increase in power density for some materials ,e.g., SiO_2 , ZnS and Ge while the increase in power density leads to reduce the total refractive index for other materials like BaF_2. The total absorption coefficient increased with power density increase for all materials under study. We also found that an increase of 1K in material temperature leads to about 0.5% increase in ΔT_{pv} for all materials under study . The detector aperture controls the amount of power that reach to the detector. When large aperture is used, the detector will sense the absorption of sample while when using small aperture the detector can sense the change of power density by overrule the transmittance of aperture. To obtain accurate results, this aperture value of S must be between 0.4-0.6. The Zscan experiment conditions must be chosen by balancing between laser

wavelength and focusing focal length. The effect of nonlinear absorption coefficient is found to be insignificant and can be ignored in measurements and calculations. The limitations in the Z-scan experiment should be considered prior to any experiment. They are related to minimum and maximum laser power density, the material type and temperature, and the sample length. These limitations were calculated for the investigated optical materials .

Finally, a Visual Basic was used to simulate and design a Z-scan experiment based on the present calculations. The Z-scan profile and the expected result for the nonlinear refractive index of materials and

experimental limitations can be evaluated via this program.