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PHOTOSTABILITY AND NON-LINEAR PROPERTIES OF POLYMER-NANOPARTICLES COMPOSITES

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Abstract. In this research the nonlinear optical properties (NOP) of nanocomposite material based on chalcogenides and gold nanoparticles in a polymer medium was studied using the Z-scan method. Since in Z-scan method the material should be exposed to a strong laser radiation, it was necessary at first to study the effect of irradiation on the material, to evaluate its Laser Durability and photostability.

Introduction. The nonlinearities of nanostructured materials have attracted a great interest due to the considerable enhancement of their nonlinear properties caused by quantum size effects. To date, a lot of work has been devoted to the study of the nonlinear optical properties of chalcogenides in the form of films, bulk materials, and colloidal solutions. However, much less studies were devoted to investigate the nonlinear optical characteristics of chalcogenide or gold nanoparticles embedded in optical media. Therefore, the aim of this work was to study the nonlinear optical properties of polymer nanocomposites with chalcogenide and gold nanoparticles in comparison with films of the same materials obtained by the deposition method.

Materials. The photostability and nonlinear properties were studied in the polymer films of four compositions: 1- pure polymer nanocomposite; 2- As2S3-nanocomposite; 3- SiO2-nanocomposite; 4- Au – SiO2-nanocomposite. Moreover, As2S3 and gold films obtained by thermal spraying on glass were used to compare their nonlinear characteristics with nanocomposite ones.

Laser Irradiation Durability. To study laser irradiation durability two different lasers were used:

- Femtosecond laser (Ti: S). λ= 806 nm, pulse mode with a frequency of 1 Hz, pulse duration 35 fs, pulse energy 2 mJ.
- Nanosecond laser (Nd:YAG). λ=1064nm, pulse duration 10 ns, pulse energy 210 mJ.

After irradiation the surface defects were studied using an optical microscope, and it was found that:

1. Noticeable defect appears at an energy density of $0.6 * 10^{-3}\ J/cm^2$, and optical breakdown of the polymer film is observed at an energy density of $0.84 * 10^{-3}\ J/cm^2$. It should be mentioned that this power density is comparable to the power density of the optical breakdown of silica glasses, which means that the obtained composites have a high optical breakdown threshold.
2. The introduction of As2s3 nanoparticles significantly increases the laser stability of the material that even at high exposure power of single pulses, no defects were observed on the surface.
3. The presence of Au nanoparticles in the nanocomposite did not influence the optical breakdown threshold. However, studying the surface by an interferometer, it was found that the gold nanoparticles decreased the size of the breakdown spot by a 20%. Which can be explained by the plasmonic effect of gold nanoparticles initiating polymerization on the surface of a silicon oxide nanoparticle and therefore the formation of a stronger nanocomposite structure.

Photostability. Investigations of the photostability of nanocomposites were carried out using a 532 nm continuous DPSS laser. The photostability of the following nanocomposites was studied, SiO2-nanocomposite with and without Au nanoparticles, and samples with and without As2S3 nanoparticles. The following results were obtained by comparison the transmission spectra of the samples before and after laser exposure:

- For SiO2-nanocomposite with and without Au nanoparticles no change was observed in the optical transmission spectra in the range from 300 nm to 1100 nm.
- For As2S3 nanocomposite, the spectrum exhibits a shift of the absorption band edge to the short-wavelength side, which is explained by photo-induced structural changes.

Nonlinear Refractive Index Measurement by Z-scan Technique. Z-scan technique is used to measure the non-linear refractive index n2. The calculation of the nonlinear refractive index of the samples was carried out according to the known regulations. To extract any possible influence of the substrate on the measurements, at first only the substrate was studied, and then the entire sample.
In result, the nonlinear refractive indices of the following samples were obtained:

- As2S3 nanocomposite: $n_2 = 5.9255 * 10^{-15}\ cm^2/W$ and As2S3 thin film $n_2 = 1.8204 * 10^{-13}\ cm^2/W$.
- Nanocomposite with Au nanoparticles $n_2 = 2.6 * 10^{-15}\ cm^2/W$.

Conclusion. The photostability and laser irradiation durability of different nanocomposites based on As2S3; SiO2; and Au nanoparticles doped in polymer matrices were studied. The nonlinear refractive index was measured by Z-scan technique, calculated for different compositions and compared with thin films of the same materials.

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