

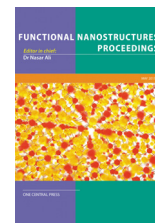


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Operation by optoelectronic features of photopolymer embedded nanocrystallites

Katarzyna Ozga^{1*} and Iwan Kityk¹

¹Institute of Optoelectronics and Measuring Systems, Faculty of Electrical Engineering, Czestochowa University of Technology, Armii Krajowej 17 Str., 42-200 Czestochowa, Poland.

*corresponding author

ABSTRACT

We have shown a possibility to operate by nonlinear optical susceptibilities of the semiconducting nanocrystallites embedded within the photopolymer poly(vinyl alcohol) (PVA) matrix. The nonlinear third order optical properties were studied for the fundamental wavelength of the 1540 nm for the third harmonic generation (THG) at 513 nm. It is explored dependence of the observed effect versus the nanocrystallite sizes, concentration and power density of the photoinduced beam. The crucial role of the thin interface (nanocrystallite/matrix) nanolayers possessing enhanced dipole moments is demonstrated. The space distribution of the nonlinear optical efficiency is explored.

I. INTRODUCTION

The search of new optoelectronic materials based on polymer is very hot topics of modern materials science [1]. Among the optoelectronic features very crucial are now material which may be operated by external laser light [2]. This one allows to change the optoelectronic properties of one synthesized composites many times only by change of the laser illumination. The coherent laser treatment effectively changes the interfaces between the nanocrystallites and the surrounding matrix polymer. The process of photopolymerization is very efficient for operation by the thin nanosheet thickness (up to 4 nm). The space between the nanocrystallites and the polymer which in turn change the local hyper polarizabilities and total macroscopical susceptibilities.

The present work is devoted to studies of the laser operated PVA photopolymers with embedded semiconducting nanocrystallites. The principal role in the observed effects plays photopolarization which increases due to close spectral position of the THG wavelength with respect to the absorption edge and contribution of the anionic originated anions. The influence of the photoinduced power density on the output induced nonlinear optical constants is explored both within the phenomenological and microscopical approaches. The photo-thermal stability during many cycles of laser illumination is explored. During photoillumination there occurs some space separated patterns in the THG which may be caused by a specific interaction of the fundamental and the output frequency tripled coherent beams.

II. EXPERIMENTAL

Materials. As the nanocrystallites we have used semiconducting ZnO, ZnS, CdS, GaN nanocrystallites prepared by electrolysis. The sizes of the nanoparticles (NP) were varied within the 5 nm...30 nm. The additional mechanical and acoustical milling were performed. The process of the synthesis was performed with addition of the PVA which have defined the sizes of the NP. The separation of the NP was done using the nanopores membranes in applied electrostatic field. The content of the nanoparticles was varied from 10 % in molecular weight up to 45 %.

Experimental Set-up. For the studies we have used the photoinduced THG of the nanoparticles using a set-up

presented in the Fig. 1. The fundamental Er: glass nanosecond pulsed laser at wavelength 1540 nm and pulse frequency repetition about 10 Hz has served as a source of fundamental illumination. The beam profile of the fundamental laser were close to the Gaussian-like. The 300 mJ cw 1060 nm laser was used for the performance of the photo induced changes. The process of illumination was done during 20...30 s up to saturation and after the switching off during the 5...7 s the process of the measurements THG was carried out.

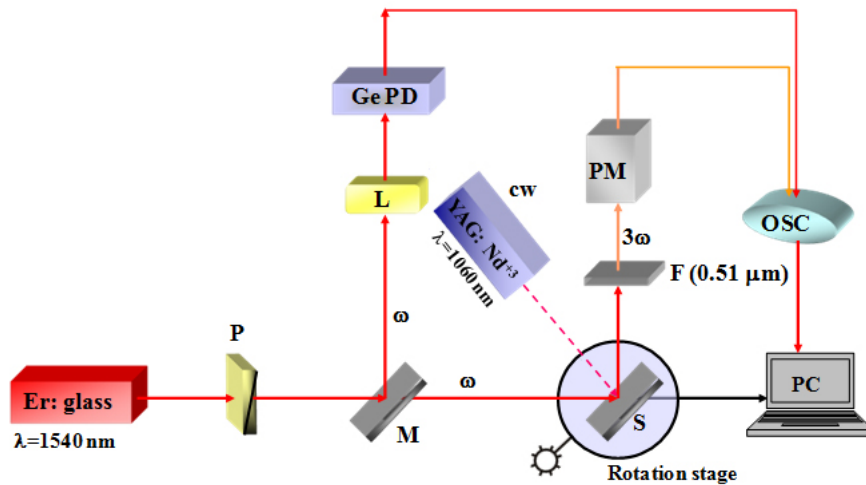


Figure 1 Principal set-up for the measurements of the photoinduced THG: Er: glass – fundamental Er: glass laser at 1540 nm with frequency repetition about 10 Hz; M – semi-transparent mirror; L – lens; Ge PD – control photodiode; PM – photomultiplier; S – sample; OSC – 1 GHz oscilloscope; YAG: Nd³⁺ cw diode pumped laser; F – green filter at 513 nm.

III. RESULTS AND DISCUSSION

The typical TEM picture of the such prepared nanocomposites is shown in the Fig. 2. The JEOL 2000 microscope operating at 200 kV and with a point resolution of about 0.35 nm was used. TEM imaging was done in bright field approach.

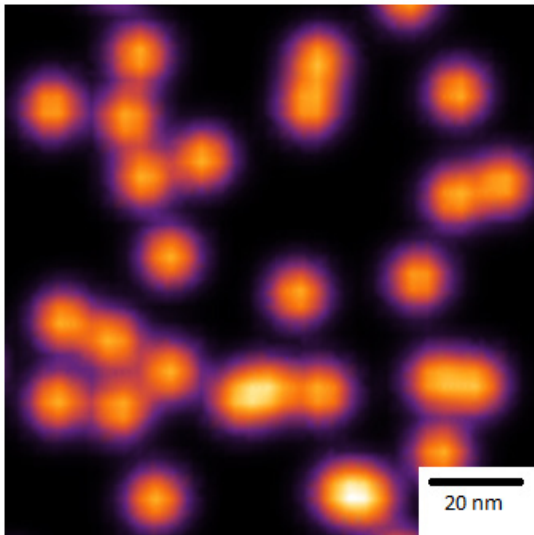


Figure 2 Typically PC reconstructed TEM pictures of the titled CdS embedded nanocomposites.

Among the laser operated optoelectronic features we are concentrated on the studies of the laser induced third harmonic generation presenting the third order nonlinear optical effects described by the fourth rank tensors. The output THG signal was additionally controlled by CCD and the principal images are given in the Fig. 3. One can clearly see that at relatively low content (about 6 %) we observe the quasiperiodic THG space patterns and for the higher content the frequency is higher. The latter are a consequence of superposition of the nanoparticles contribution and the surrounding polymers.

The studied laser induced THG versus different power density for the CdS nanoparticles with different sizes are shown in the Fig. 4. From this figure one can clearly see that the laser induced THG increase with decreasing sizes and it appears a maximum which is shifted towards less energies with decrease of the sizes.

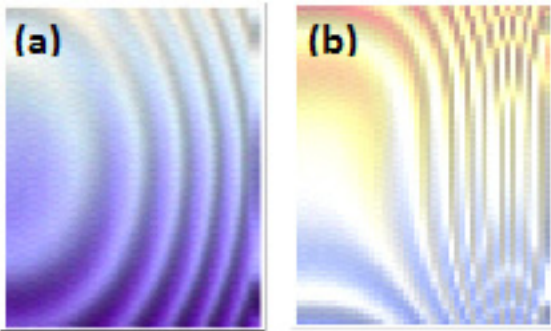


Figure 3 An example of typical space distribution of the output THG for the CdS/PVA nanocomposites with different content: (a) 6 %; (b) 12 % in the PVA matrices. Under 400 MW/cm² bicolor laser treatment.

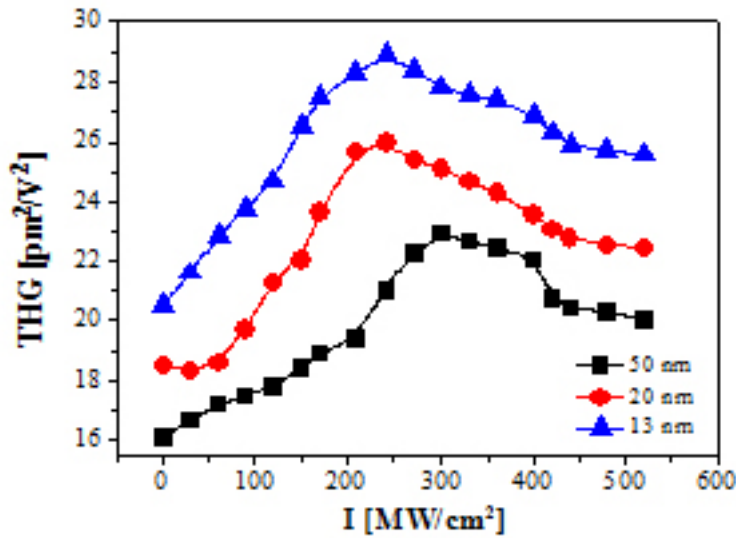


Figure 4 Typical dependence of the laser induced THG for the CdS NP with different sizes.

The presented in the Fig. 4 results unambiguously demonstrate an opportunity to operate by the output NLO features using the external photoinduced light power and the THG efficiency depends both on the photoinduced power as well as on the nanoparticles sizes increasing with the decrease of the sizes.

IV. SUMMARY

It demonstrates a principal opportunity to operate by the third order nonlinear optical susceptibility of the semiconducting nanocomposites in the photopolymer PVA matrices using external laser beam. It is shown that for the CdS/PVA nanocomposites there exists some optimal photoinduced powers favoring enhanced THG which decrease with the NP sizes. The origin of the effect is discussed.

V. REFERENCES

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