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Nonlinear optical properties of metal alkanoate composites with hybrid core/shell nanoparticles

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Core/shell nanoparticles (NPs) are attracting more and more attention, since these NPs are highly functional substances with modified properties. The purpose of the coating on the nanoparticle core is very diverse, such as surface modification, the ability to increase the functionality or stability, reduction in consumption of precious materials, and so on. The some applications of different core/shell NP are summarized in a review [1].

Features of structure and nonlinear optical properties of metal alkanoate (Cd+2(COOC7H15)-2 (abbreviation CdC_8) composites with hybrid core/shell nanoparticles: Au/CdSe and CdSe/ZnS have been studied by using small-angle X-ray scattering method and Z-scan technique. New NPs were chemically synthesized in liquid crystal phase of cadmium octanoate (T = 100-150C) in two stages. At first in the liquid crystal matrix were synthesized Au or CdSe nanoparticles. Further synthesis of shell NPs in cadmium octanoate composites were performed of CdSe or ZnS depositing on previously obtained Au or CdSe nanoparticles. According to X-ray data, the total diameter of CdSe/ZnS core/shell nanoparticles is 11.8 nm, diameter CdSe-core is 6.4 nm, diameter ZnS-shell is 2.7 nm. The dispersion of core/shell NPs size is very small. After the synthesis the said nanocomposites are cooled down to the room temperature and formed anisotropic glasses.

The nonlinear optical properties of the core/shell NPs embedded in cadmium octanoate glassy matrices have been investigated by applying Z-scan technique with using the nanosecond pulsed Nd:YAG laser at 0.5 Hz pulse repetition rate on a wavelength of 532 nm.

The normalized transmission of cadmium octanoate composites with core/shell NPs (Au/CdSe and CdSe/ZnS) as function of the distance z for open and close aperture of Z-scan were obtained. The calculated nonlinear optical coefficients of the test samples are presented in Table 1.

Samlpe	L, мм	α, cm^{-1}	I_0, MW/cm^2	n_2, cm^2/W	β, cm/W	Re$\chi^{(3)}$, esu	Im$\chi^{(3)}$, esu	$\|\chi^{(3)}\|$, esu	FOM_{2PA}
CdC_8(CdSe-ZnS)	20	219.25	41.4	2.43Ч10^{-10}	7.46Ч10^{-6}	1.04Ч10^{-8}	1.7Ч10^{-9}	1.06Ч10^{-8}	0.61
CdC_8(Au-CdSe)	20	281.94	13.96	2.27Ч10^{-10}	2.11Ч10^{-5}	0.97Ч10^{-8}	5.08Ч10^{-9}	1.1Ч10^{-8}	0.2
			17.91	3.97Ч10^{-10}	3.29Ч10^{-5}	1.7Ч10^{-8}	7.93Ч10^{-9}	1.87Ч10^{-8}	0.23
			19.05	4.55Ч10^{-10}	4.98Ч10^{-5}	1.95Ч10^{-8}	1.2Ч10^{-8}	2.59Ч10^{-8}	0.17

Earlier it was found [2], that the ZnS-shell helps to enhance the luminescence (on 50% quantum yield) of the CdSe-core. As can be seen from table 1, our nanocomposites (CdC_8+CdSe/ZnS) exhibit relatively large and high-speed electronic third-order optical nonlinearity of CdSe-core coating by ZnS-shell. According to the experimental data, sign of the nonlinear absorption coefficient of nanocomposites CdC_8 + CdSe/ZnS is positive, в>0 and the sign of the nonlinear refractive index is also positive, n2 >0 (the self-focusing is observed).

Due to manifestation of the surface plasmon resonance of Au-core NPs and the interband electronic absorption of CdSe-shell in the visible spectral range (450 – 650 nm) the nanocomposites (CoC_8 + Au/CdSe) also exhibit large and fast third-order optical nonlinearity (Table 1) by scanning of the samples with laser radiation on wavelength 532 nm. The sign of the nonlinear absorption coefficient of the CdC_8 + Au/CdSe nanocomposites is positive, в<0. The sign of nonlinear refractive index of CdC_8 + Au/CdSe nanocomposite is positive, $n_2 > 0$ (the self-focusing is observed). Semiconductor coatings ZnS-shell and CdSe–shell) of CdSe-core and Au-core NPs promote self-focusing of investigated nanocomposites. Such nanomaterials with large third-order optical nonlinearities and fast nonlinear optical response are usually considered promising candidates for use in optoelectronic and photonic applications.

References

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