Nanocomposites and nanomaterials

Resonance excitation of the noble metal nanoparticles embedded in the linear and nonlinear optical metal alkanoate matrices.

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Nanocomposites with high third-order optical nonlinearities and fast nonlinear optical response are usually considered as promising candidates for use in optoelectronic and photonic applications. The various composites with metal nanoparticles (NP) exhibiting these properties were reported in numerous papers, for example [1, 2]. In our paper the nonlinear optical properties of the noble metal NP Ag and Au embedded in different metal alkanoate matrices have been investigated by applying Z-scan technique. The nanosecond laser pulses on a wavelength of 532 nm were used for excitation of the nanocomposites. As template the two representatives of the metal alkanoate class were taken: cobalt octanoate (abbreviated as CoC8) absorbing light in the wide spectral region at 532 nm and cadmium octanoate (abbreviated as CdC8) does not absorbing light in the near-UV-visible spectral area. Silver and gold NP exhibit the surface plasmon resonance (SPR) located also in the near-UV-visible spectral range. Two major types of metal-dielectric nanocomposites were considered: 1) nonlinear inclusions (noble metal NP) embedded in the linear cadmium octanoate matrix, and 2) nonlinear same inclusions in the nonlinear cobalt octanoate matrix.

The Au NP and Ag NP were chemically synthesized in thermotropic ionic liquid crystal (ILC) phase (T = 100-1500C) of cobalt octanoate and also of cadmium octanoate. After the synthesis the said nanocomposites are cooled down to the room temperature and form anisotropic glasses. The measurement of Au NP, Ag NP sizes and shape embedded in different matrices were carry out by small-angle X-ray scattering analysis and by the transmission electron microscope (TEM). A nanosecond pulsed Nd:YAG laser with pulse duration τ = 20 ns at a 0,5Hz pulse repetition rate was used in Z-scan experiments. The nonlinear optical characteristics of nanocomposites were obtained at laser second harmonic at the wavelength 532 nm. The laser radiation was focused by lens of f=8,5cm focal length. In during Z-scan experiment the samples were moved using a translation system along the z-axis through the focusing area. The beam waist radius at the half height of the laser intensity distribution is w0 = 25 μm. A 2 mm aperture was used in closed-aperture Z - scheme. The normalized transmission of pure CoC8 (absorbent) matrix and Au : CoC8, Ag : CoC8, and Au : CdS, Ag : CdS composites as function of the distance z for open and close aperture of Z-scan at laser intensity interval (I0 = 7,4 – 37,99 MW/cm2) were obtained. The calculated nonlinear optical coefficients of the test samples are presented in Table 1.

Samlpe	L, μm	α, cm^{-1}	I_f, MW/cm^2	n_2, cm^2/W	β, cm/W	Re$\chi^{(3)}$, esu	Im$\chi^{(3)}$, esu
CdC_8+ 4mol% Ag	23	508.18	10.45	--	-9.172×10^{-5}	--	-2.212×10^{-8}
			17.69	-3.905×10^{-10}	-7.502×10^{-5}	-1.669×10^{-8}	-1.809×10^{-8}
			26.45	-5.031×10^{-10}	-4.739×10^{-5}	-2.151×10^{-8}	-1.143×10^{-8}
			37.99	-6.961×10^{-10}	-3.105×10^{-5}	-2.976×10^{-8}	-0.749×10^{-8}
CdC_8+ 4mol% Au	22	423.43	10.85	--	-1.288×10^{-5}	--	-0.311×10^{-8}