Optical and Nonlinear Optical Characterization of Nanosized ZnO

V. Multian[1], A. Uklein[1], O. Boldyrieva[2], V. Lisnyak[2], V. Gayvoronsky[1]

[1]*Institute of Physic of National Academy of Science of Ukraine, 46 Prospect Nauky, 03028 Kyiv, Ukraine*
[2]*Taras Shevchenko National University of Kyiv, Chemical faculty, 62a Volodymyrska Str., 01601 Kyiv, Ukraine*

Wide-gap semiconductor ZnO is characterized with high binding energy of Wannier-Mott excitons (~60 meV) and promising luminescence efficiency. ZnO nanoparticles (NPs) are widely applied in the fields of optoelectronic devices [1]. ZnO NPs have shown a high potential for the biolabeling application [2] that require the NPs size reduction (at least less than 100 nm) within maintaining the same level of the SHG efficiency. Ultra-small size ZnO NPs or QDs should be synthesised for advanced biolabeling under size controlled technique because these particles possess valuable electro-optical properties that differ from their bulk counterparts, and being sensitive to both NP's size and shape.

In the present communication, we report on the nonlinear optical (NLO) properties and SHG efficiency of ultra-small NPs. ZnO NPs with the efficient luminescent and quadratic NLO responses were prepared by a hydrolytic route. The resulted ZnO NPs were characterized with optical and IR spectroscopies. Core stabilization, at the early stages of hydrolysis, limits the further growth. The average size of NPs was estimated to be within 2.0–2.8 nm with absorption measurements. The PL emission and UV-Vis absorption increase with the content of NPs. The efficiency growths from the particles isolated from EtOH to that from MeCN. The PL bands were analysed and the respective band area was addressed to the oxygen vacancies.

The NLO characterization of ZnO NPs was provided by the self-action effect monitoring within the picosecond laser pulses at 1064 nm. It was shown the ZnO NPs isolated from solvents of different nature have a diverse efficiency of the absorptive and refractive NLO responses. The correlation between the $\mathrm{Im}(\chi^{(3)})$ magnitude and the oxygen deficiency in ZnO was shown.

The second harmonic generation (SHG) in the ZnO NPs was studied under the femtosecond-laser excitation at 800 nm. The SHG efficiency is comparable for ZnO NPs of ~2 and ~150 nm. For biolabeling applications, this effect is quite important, if one apply the SHG response techniques with small ZnO NPs.

[1] T. Mei, Y. Hu, Synthesis, self-assembly and optoelectronic properties of monodisperse ZnO quantum dots, Optoelectronic Devices and Properties, Ed. Sergiyenko O, InTech China, Shanghai; pp. 215–240 (2011).

[2] C. Joulaud, Y. Mugnier, G. Djanta, M. Dubled, J.-C. Marty, C. Galez, J.-P. Wolf, L. Bonacina, R. Le Dantec, Characterization of the nonlinear optical properties of nanocrystals by Hyper Rayleigh Scattering, *J. Nanobiotechnology* **11**:S8 (2013), doi:10.1186/1477-3155-11-S1-S8.