Chapter 23
Volumetric, Glass-Based Luminescent Nanocomposites Produced Using the NPDD Method

Rafał Nowaczyński, Marcin Gajc, Hańcza B. Surma, Piotr Paszke, Kamil Szlachetko, Piotr Piotrowski, and Dorota A. Pawlak

Abstract NanoParticle Direct Doping (NPDD) (Gajc and Pawlak, Adv Funct Mater 23:3443, 2013) is a method developed in the Institute of Electronic Materials Technology in Warsaw that allows fabrication of volumetric composites based on low-melting-point glass matrices doped with various kinds of nanoparticles (NPs), including metallic plasmonic NPs and Quantum Dots (QDs). It is based on a Micro-Pulling down method, in which dry powders of the matrix and dopants are mixed together, heated until the matrix melts and then pulled in a form of a rod.

Here we show that it is possible to obtain composite material doped with silver NPs with diameter of 20 nm, based on a sodium borophosphate dielectric glass (NBP), which is transparent over wide range of wavelengths and exhibits melting temperature of ca. 750 °C (Gajc and Pawlak, Adv Funct Mater 23:3443, 2013). It results in Localized Surface Plasmon Resonance (LSPR) peak visible on the absorbance spectrum of the material with maximum at 405 nm. It is also possible to co-dope the composite with QDs. Addition of Ag NPs results in the enhancement of the 510 nm excitonic emission from CdTe QDs compared to the material doped only with QDs.

The NPDD method allows us to combine different types of NPs. Even after co-doping simultaneously with hydrophilic CdTe QDs (λ_{em} = 730 nm) and hydrophobic, core-shell CdSe/ZnS QDs (λ_{em} = 530 nm) material exhibits dual-

R. Nowaczyński (✉)
Faculty of Materials Science and Engineering, Warsaw University of Technology, Warsaw, Poland

Faculty of Chemistry, University of Warsaw, Warsaw, Poland
e-mail: rafal.nowaczynski.dokt@pw.edu.pl; r.nowaczynski@cent.uw.edu.pl

P. Paszke · K. Szlachetko · P. Piotrowski
Faculty of Chemistry, University of Warsaw, Warsaw, Poland

D. A. Pawlak
Faculty of Chemistry, University of Warsaw, Warsaw, Poland

Institute of Electronic Materials Technology, Warsaw, Poland

M. Gajc · H. B. Surma
Institute of Electronic Materials Technology, Warsaw, Poland

© Springer Nature B.V. 2022

M. Cesaria et al. (eds.), *Light-Matter Interactions Towards the Nanoscale*,
NATO Science for Peace and Security Series B: Physics and Biophysics,
https://doi.org/10.1007/978-94-024-2138-5_23

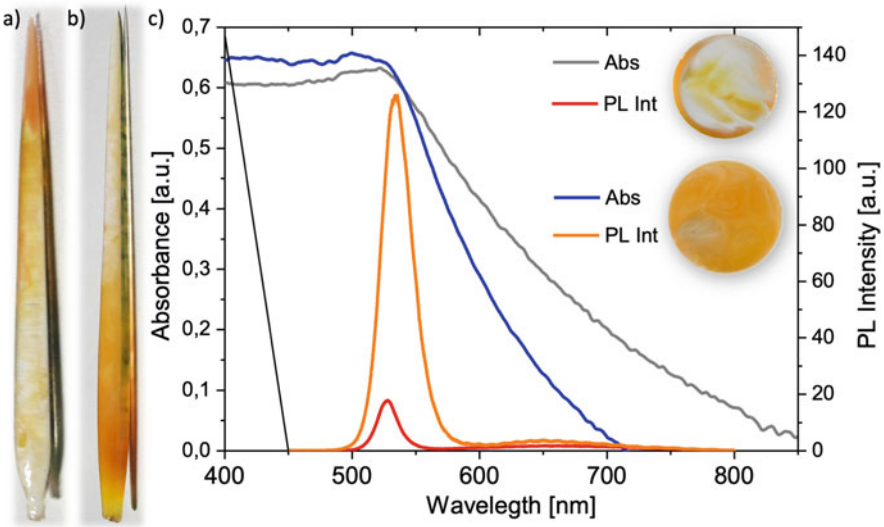

Fig. 23.1 (**a**) NBP glass rod doped with 0.3 wt.% of ZnCdSeS QDs, added to the initial glass matrix as a dry powder. (**b**) NBP glass rod doped with 0.3 wt.% of ZnCdSeS QDs, added to the initial glass matrix trough dispersion in toluene. (**c**) Absorbance and PL intensity spectra of obtained materials along with cross-sections of rods. Low homogeneity – QDs added as a dry powder, high homogeneity – QDs dispersed in toluene

wavelength photoluminescence (Nowaczynski and Pawlak Part Part Syst Charact 36:1800124, 2018). This versatility of the method can potentially allow us to construct a material doped with Ag NPs, QDs and rare-earth ions, especially Pr^{3+} to achieve narrowband Pr luminescence with laser diode excitation at wavelengths that are not absorbed well by the Pr itself. However, quality and homogeneity of composites has to be improved, which can be achieved by modification of the initial powder preparation process, like QDs dispersion in toluene prior to mixing with glass powder (Fig. 23.1).

Keywords NanoParticle direct doping · Quantum dots · Plasmonic nanoparticles

Acknowledgments The authors thank the MAESTRO Project (2011/02/A/ST5/00471) operated by National Science Centre for support of this work. This project was supported financially by the TEAM programme of the Foundation for Polish Science (No. TEAM/2016-3/29), co-financed by the European Union under the European Regional Development Fund.

References

1. Gajc M, Pawlak DA et al (2013) Nanoparticle direct doping: novel method for manufacturing three-dimensional bulk Plasmonic nanocomposites. Adv Funct Mater 23:3443
2. Nowaczynski R, Pawlak DA et al (2018) Manufacturing of volumetric glass–based composites with single- and double-QD doping. Part Part Syst Charact 36:1800124