Laser Synthesis and Heating of Semiconductor-Based Nanocomposites with Tuned Plasmonic Properties

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Synthesis of novel multi-element nanomaterials is a very demanding task for life science applications in order to perform simultaneously different actions. Pulsed laser ablation in liquids (PLALs) is a very convenient technique for forming chemically ultrapure single- and multi-element nanostructures by an easy and fast way. Recently, we have demonstrated successful merging of semiconductor and metallic elements in form of one nanoparticle (NP) that is still unexplored and challenging niche of the laser-matter interaction field [1,2].

In this research, plasmonic nanocomposites (NCs) based on either laser-generated or chemically prepared semiconductor NPs (silicon or carbon) were synthesized by means of PLALs technique. For this purpose, noble metals were immersed in aqueous colloidal solutions of semiconductor NPs and were treated with a pulsed laser irradiation (1030 nm, 6 ps, 10 kHz, 50 µJ/pulse). The presence of both metallic and semiconductor elements in NPs (confirmed by EDX studies [1]) ensure effective plasmonic and paramagnetic modalities that can be employed for sensing applications. One can easily design the NCs with tuned spectral position [2] and efficiency (Figure 1a) [2,3] of plasmonic properties by changing a metallic target and laser irradiation time. The latter reflects the variation of the irradiation time-dependent gold content studied by ICP-MS (Figure 1b).

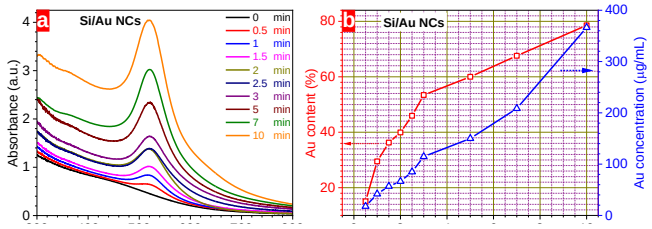

Figure 1. Tuning of plasmonic efficiency (a) and gold content (b) in Si/Au NCs by laser ablation time.

Nevertheless, the variation of the laser fluence affects neither mean size nor size distributions of plasmonic semiconductor-based NCs [4]. However, the chemical composition strongly depends on the mean size of NPs – the gold content decreases with the size of NCs [1]. Thus, one can manage the performance of the nanocomposites by playing with the experimental conditions during the laser synthesis. Indeed, apart from the previously reported SERS biosensing using Si/Au NCs, we recently demonstrated controlling of the ultrafast laser-induced heating of colloidal solutions of plasmonic semiconductor-based nanocomposites [2,3] that can be promising for mild hyperthermia or photothermal therapy applications.

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References: [1] Yu.V. Ryabchikov, *Journal of Nanoparticle Research*, **21(4)**, 85, 2019; [2] Yu.V. Ryabchikov, I. Mirza, M. Flimelová, A. Kana and O. Romanyuk, *Nanomaterials*, **14(4)**, 321, 2024; [3] Yu.V. Ryabchikov, A. Zaderko, *Photonics*, **10**, 1229, 2023. ; [4] Yu.V. Ryabchikov, *Crystals*, **13(9)**, 1381, 2023.