Laser as a tool for synthesis of metal and hybrid metal-carbon functional nanomaterials

Alina Manshina
Saint-Petersburg State University, Russia
a.manshina@spbu.ru

Laser irradiation can provide unique physicochemical conditions in the exposure area, thus initiating diversity of secondary processes related to phase transitions, structure reorganization and chemical reactions. Fine-tuning of the laser-initiated processes can be easily achieved by precise control of the optical parameters – spectral and energy characteristics, spatial localization, duration of exposure (including different regimes of laser generation – continuous or pulsed). Here the less studied and the most curious processes are connected with laser-initiated chemical reactions that result in generation of materials with diverse chemical structure and compositions.

Heterogenic systems (solid-liquid interfaces) are extremely promising targets for the laser irradiation because of a variety of chemical processes that can be initiated as a result of laser effect as compared with homogeneous systems (liquids or solids). Well and widely known approach using the highly intense laser irradiation of the interface between solid substrate and liquid phase results in many effects connected with laser ablation in liquids and the subsequent nanostructures formation.

The use of **low** intense laser irradiation of substrate-solution interfaces is an uncommon approach. However as we found, it opens a novel way of multiphase nanostructures synthesis in a single step process. It is based on laser irradiation of the substrate-solution interface; and we call it Laser-Induced Deposition (LID). As a result of laser-initiated chemical processes, nanostructures are formed in the laser-affected area of the substrate. As a liquid phase, one can use electrolyte solutions traditional for chemical metallization, or solutions of metal salts with some reducing agents, or just solutions of organometallic complexes.

A particularly simple and efficient synthesis of metallic (Ag, Pt, Co, Au, Ru …) and hybrid nanostructures that are multi-metal (Au-Ag, Cu-Ag, Pt-Ag …) nanoclusters incorporated into carbonaceous matrix will be presented in the talk [1-5]. The main competitive advantage of LID over other laser-based methods is its ability to synthesize NPs directly on any given/preselected surface area of the substrate. It allows one step and 'on-site' functionalization of various types of surfaces with NPs active in catalysis and electrocatalysis, surface-enhanced Raman spectroscopy, plasmon-enhanced fluorescence, energy conversion, solar cell technologies, etc.

Acknowledgement – the work was supported by the RFBR-DFG grant # 20-58-12015 ННИО_а

[1] A. Povolotckaia, D. Pankin, (…) G. Leuchs, and A. Manshina, Plasmonic carbon nanohybrids from laser-induced deposition: controlled synthesis and SERS properties. J Mater Sci 54,8177–8186 (2019)
[2] D. Mamonova et al. Laser-Induced Deposition of Plasmonic Ag and Pt Nanoparticles, and Periodic Arrays. Materials, 14, 10 (2021)
[3] S. Schlicht, A. Kireev, A. Vasileva et al. A model electrode of well-defined geometry prepared by direct laser induced decoration of nanoporous templates with Au–Ag@C nanoparticles. Nanotechnology 28:65405(2017).
[4] Bashouti, M.Y., Manshina, A., Povolotckaia, A., (...), Tunik, S., Christiansen, S. Direct laser writing of μ-chips based on hybrid C-Au-Ag nanoparticles for express analysis of hazardous and biological substances. Lab on a Chip, 15(7), p. 1742-1747 (2015)
[5] Bashouti, M.Y., Povolotckaia, A.V., Povolotskiy, A.V., (...), Leuchs, G., Manshina, A.A. Spatially-controlled laser-induced decoration of 2D and 3D substrates with plasmonic nanoparticles. RSC Advances, 6(79), p. 75681-75685 (2016)