Light Sensitive Plasmonic Nanostructures for Photonic Applications

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Abstract : In this work, the performance of gold nanoparticles were investigated for stimulation of photosensitive materials for photonic applications. It was widely used for surface plasmon resonance experiments, not in the last place because of the manifestation of optical resonances in the visible spectral region. The localized surface plasmon resonance is rather easily observed in nanometer-sized metallic structures and widely used for measurements, sensing, in semiconductor devices and even in optical data storage. Firstly, gold nanoparticles on silica glass substrate satisfy the conditions for surface plasmon resonance in the green-red spectral range, where the chalcogenide glasses have the highest sensitivity. The gold nanostructures influence and enhance the optical, structural and volume changes and promote the exciton generation in gold nanoparticles/chalcogenide layer structure. The experimental results support the importance of localized electric fields in the photo-induced transformation of chalcogenide glasses as well as suggest new approaches to improve the performance of these optical recording media. Results may be utilized for direct, micrometre- or submicron size geometrical and optical pattern formation and used also for further development of the explanations of these effects in chalcogenide glasses. Besides of that, gold nanoparticles could be added to the organic light-sensitive material. The acrylate-based materials are frequently used for optical, holographic recording of optoelectronic elements due to photo-stimulated structural transformations. The holographic recording process and photo-polymerization effect could be enhanced by the localized plasmon field of the created gold nanostructures. Finally, gold nanoparticles widely used for electrochemical and optical sensor applications. Although these NPs can be synthesized in several ways, perhaps one of the simplest methods is the thermal annealing of pre-deposited thin films on glass or silicon surfaces. With this method, the parameters of the annealing process (time, temperature) and the pre-deposited thin film thickness influence and define the resulting size and distribution of the NPs on the surface. Localized surface plasmon resonance (LSPR) is a very sensitive optical phenomenon and can be utilized for a large variety of sensing purposes (chemical sensors, gas sensors, biosensors, etc.). Surface-enhanced Raman spectroscopy (SERS) is an analytical method which can significantly increase the yield of Raman scattering of target molecules adsorbed on the surface of metallic nanoparticles. The sensitivity of LSPR and SERS based devices is strongly depending on the used material and also on the size and geometry of the metallic nanoparticles. By controlling these parameters the plasmon absorption band can be tuned and the sensitivity can be optimized. The technological parameters of the generated gold nanoparticles were investigated and influence on the SERS and on the LSPR sensitivity was established. The LSPR sensitivity were simulated for gold nanocubes and nanospheres with MNPBEM Matlab toolbox. It was found that the enhancement factor (which characterize the increase in the peak shift for multi-particle arrangements compared to single-particle models) depends on the size of the nanoparticles and on the distance between the particles. This work was supported by GINOP- 2.3.2-15-2016-00041 project, which is co-financed by the European Union and European Social Fund. Istvan Csarnovics is grateful for the support through the New National Excellence Program of the Ministry of Human Capacities, supported by the ÚNKP-17-4 Attila Bonyár and Miklós Veres are grateful for the support of the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

Keywords : light sensitive nanocomposites, metallic nanoparticles, photonic application, plasmonic nanostructures
Conference Title : ICMPCP 2018 : International Conference on Metamaterials, Photonic Crystals and Plasmonics
Conference Location : Amsterdam, Netherlands
Conference Dates : May 10-11, 2018