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GOLD NANOPARTICLES ASSEMBLY ON GROOVED POLYMER TEMPLATES AND ANALYSIS OF THEIR OPTICAL PROPERTIES

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Introduction. The assembly of gold nanoparticles (AuNPs) using laser-induced preparation of nanostructures has emerged as a promising approach for creating highly ordered and functional nanomaterials. AuNPs are particularly attractive due to their unique optical, electronic, and catalytic properties, which are highly dependent on their size, shape, and spatial arrangement [1,2]. In this study, the optical properties of the assembled structures were analyzed using finite element simulations, revealing tunable near-field optical responses. And we demonstrate the use of maskless femtosecond laser two-photon polymerization (2PP) [3]to fabricate polymer templates with tetragonal and hexagonal patterns that can be used to orient and assemble AuNPs into structures with tunable optical properties. This approach creates new avenues for the design of functional nanomaterials with applications in photonics, plasmonics, and biosensing [4,5].

Main part. CST Studio Suite was used to construct model simulations of AuNPs fitting into nanostructured grooves. The scattering cross-section properties of near-field optics in the corresponding cases are investigated by varying the trench size (10-250 nm), the angle of incident light (0-88°), and the direction of electric field polarization of the incident plane wave, respectively, while satisfying that the nanogap between the nanoparticles and the trench (2 nm) is sufficiently small. Polymer templates were prepared based on two-photon polymerization (2PP) technique. Prebaked (80 °C, 40 min) photoresist FemtoBond was dropped on a 170 μm thick glass sheet and inverted on an air-suspended panning stage from Aerotech Inc. The scanning trajectory (CAD model in STL format) was controlled by software developed by Laser Zentrum Hannover e. V. TiF-100 Ti:Sapphire femtosecond laser (pulse width 100 fs, repetition frequency 80 MHz) from AVESTA was used, and the laser was rapidly switched on and off by an acousto-optic modulator, and focused through a 100x oil immersion objective (NA=1.4) inside the photoresist droplet near the lower surface of the slide to form a predefined polymer template. The laser power was stabilized at 13.5 mW and the scanning speed was 15 μm/s. 2PP-prepared samples were developed in propanol for 1 h to remove unpolymerized photoresist.

Conclusion. The results show that the electromagnetic field is strongly coupled to the collective oscillations of free electrons at the metal-dielectric interface, leading to a significant increase in the scattering cross section. Also accompanied by different size matching, when two AuNPs are close to each other, their near fields (e.g., localized surface plasma fields) overlap with each other, leading to energy exchange and mode hybridization. The hot spots generated by such field enhancement effects are important in applications such as surface-enhanced Raman scattering (SERS). The single-layer nano-fine polymer substrates made based on 2PP conformed to the software-set dimensions with adjustable tolerances in the range of 10-20 nm, which is of practical importance for subsequent assembly of AuNPs to limit the nanogap.

References:

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