FS-LASER MICROPROCESSING FOR SERS SUBSTRATES OF PERIODIC METALLIC STRUCTURES

Kernius Vilkevičius[1], Ilja Ignatjev[2], Evaldas Stankevičius[1]

[1]Department of Laser Technologies, Center for Physical Sciences and Technology, Lithuania
[2]Department of Organic Chemistry, Center for Physical Sciences and Technology, Lithuania
kernius.vilkevicius@ftmc.lt

Direct laser writing with single pulses of a tightly focused fs-laser beam enables fast fabrication of metallic nanostructures on thin films. The most common fabricated metal is gold, whose nanostructures' morphology depends on the pulse fluence. Wavelength-sized structures exhibit plasmonic properties, while the periodic arrangement of these makes it possible to achieve hybridized plasmons [1]. As plasmonic structures have an enhanced local electromagnetic field, they can be used in surface-enhanced Raman spectroscopy (SERS). The ordinary Raman scattering signal of the molecules is quite weak, thus the local enhancement leads to a significant amplification of the signal, making it suitable for single-molecule detection. The SERS signal intensity depends on the shape of the structure, as the strongest enhancement is observed at sharp corners called hot spots [2].

The periodic Au nanostructures on thin films of different thicknesses were fabricated using 343 nm wavelength pulses of varying fluences. This was done to investigate the effect of morphology and film thickness on the observed signal. The samples were covered with a monolayer of 4-mercaptobenzoic acid (4-MBA) for SERS detection. The variation in the fluence that leads to the distinct morphological states obtained results in different signal enhancement, with the round-shaped bumps having a weak response and needle-like jets providing a strong enhancement. The latter intensity depends on the needle tip size, as the hot spots are excited there. As the layer is thickened, the formation principle, as well as the jet shape itself, changes, leading to an additional tunability in the SERS signal. By varying these parameters and selecting the optimum conditions, it is possible to achieve a signal enhancement factor of 10^7, suitable for precise detections of molecules.

The authors acknowledge the Research Council of Lithuania (LMT, Lithuania) for the received funding under project No. S-MIP-23-32.

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