Surface Enhanced Raman Scattering Studies of Femtosecond Laser Written Ripple-like Nanostructures in Air and Vacuum

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Abstract: Ripples were directly fabricated on the surface of crystalline Si by femtosecond (fs) laser irradiation both in air and vacuum to investigate the effect of the ambient processing conditions on their surface-enhanced Raman spectroscopy (SERS) response. Ripples produced in air display SERS signals almost an order of magnitude larger than those generated under vacuum, as a consequence of a more effective back-deposition of nanoparticles (NPs) during ablation in air that enhances the surface nano-roughness. SERS efficiency is further enhanced by decoration of the surface ripples with Au NPs thanks to excitation of surface plasmon resonance and creation of concentrated hot spots among the Au NPs. SERS mapping imaging showcases a good uniformity of the rippled substrates and demonstrate a great difference in the signal intensity between ripples generated in air and vacuum. A high Raman enhancement factors of 10^9 is achieved that results in good agreement with the prediction of finite-elements method simulation of the electric field enhancement. Our observations confirm the feasibility of the method and the role of the processing ambient for the fs direct laser fabrication of SERS substrates.

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