Reusable Gold Nanostars Substrates for Signal Amplification for Diagnostics

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Overview

Numerous spectroscopic techniques utilize signal enhancement from surfaces of nanoparticles linked to analyte molecules. However, existing surface-enhanced spectroscopies (SES) are based on solution-based nanoparticles dispersion and are unsuitable for solid substrates. Dr. Shimanovich and her team (led by Dr. Solomonov) have developed a set of spiked gold nanostructures (also called â€œnanostarsâ€, â€œnanoflowersâ€, â€œnanourchinsâ€) embedded directly on solid-state substrates. These functionalized nanostar-substrates enable signal amplification in solid substrates and serve as highly sensitive transducers in various spectroscopies, including surface-enhanced Raman (SERS), surface-enhanced circular dichroism (SECD), localized surface plasmon resonance (LSPR), and surface-enhanced fluorescence spectroscopy (SEFS) of molecules of biological, organic or inorganic origin.

The Need

Surface-enhanced spectroscopies (SES) utilize the enhancement of signals from surfaces of nanostructured substrates that are linked to analyte molecules (directly or indirectly). SES methods, including SERS, SECD, SEFS, LSPR, and other spectroscopy techniques using the plasmonic effect generated by the nanostructured surfaces, are applied as characterization techniques with highly localized chemical sensitivity. The available synthesis approaches are complex, and the final product often (1) ends up with signal-interfering capping agents; (2) suffers from substrate instability; or (3) has an insufficient signal enhancement, which limits the broad applicability of SES technologies.

Current approaches describe the development of SES transducers mostly in liquid solutions rather than directly on solid substrates due to the weak adhesion of gold structures onto glass substrates from one side and low corrosion resistance of e.g., silver from another side.

The Solution

Prof. Shimanovich and her team developed novel SES-active surfaces based on the growth of spiked gold nanostructures (â€œnanostarsâ€) directly onto solid substrates.

Technology Essence

The morphology of the embedded gold nanoparticles is modified to increase gold nanoparticle roughness and to vary the shape of the nanostructures forming so-called gold â€œnanostarsâ€ with gold spikes. The team produced these nanostars on the surface of a solid substrate using a simple 3-step formation procedure. These synthesized nanostructures showed increased electromagnetic field distribution at sharp edges. The partial embedding of the nanostars into the glass matrix allows their modifications and overcomes the intrinsic

complexity of lack of stability. The coated substrate stability is very high, allowing modification of the gold structuresâ€™ surface by lithographic techniques.

Applications

- Surface enhanced spectroscopic measurements, including SERS, SECD, LSPR, and SEFS
- and tip-enhanced techniques
- Diagnostics - Medical and chemical sensors that enhance weak signal
- Catalytic processes
- Stable transducers
- Optical filters in different wavelengths
- Microfluidic devices

Advantages

- Low signalsâ€™ amplification
- Detection efficiency improvement
- Facile and simple procedure
- Surfaceâ€™s lithographic modifications
- Stable in short-cycle reusability and a wide range of pH and temperatures
- High scalability

Development Status

The group developed a novel method to form stable transducers of gold nanoparticles embedded into a solid-state substrate. They demonstrated that the coated substrates amplify the signals of various wavelengths based on the plasmonic properties of the structured gold nanoparticles. The team also applied the developed substrates successfully to improve SERS signal, SECD, and LSPR of small active molecules.

Market Opportunity

SES substrates have many uses in various markets such as biology, diagnostics, optics, and medical. They can be used for various biological diagnostic methods as well as to enhance catalytic reactions, develop sensor devices and microfluidic-based chips and devices. In general, the developed substrates could be utilized for any system where the amplification of the low signals would improve the detection efficiency.