SERS-active substrates based on porous silicon

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Introduction

Surface-Enhanced Raman Scattering (SERS) is a plasmonic-based process characterized as a label-free and high-sensitive spectroscopy. SERS is a technique that was developed to detect extremely small quantities of molecules by determining their characteristic Raman signal. The high sensitivity of SERS is mainly due to electromagnetic interaction given by an effective, evanescent field enhancement on the metal surface based on the excitation of surface plasmon-polariton modes. By generating metallic nanostructures with different shapes/dimensions, it is possible to tune the plasmon resonance. Moreover, 3D metallic nanostructures with particularly large active surfaces lead to the increase of the sensitivity since more molecules are adsorbed in the focus area of the laser in comparison to conventional 2D SERS active surfaces.
The intrinsic properties of the metal nanostructures can be tuned by controlling their shape, size, and crystallinity. To date, many approaches have been developed to prepare Ag nanostructures in different shapes, like wires, prisms, cubes and others. Recently, extensive interest has been expressed in the synthesis of more complex hierarchical structures that are ideally composed of nanocrystals (particles, rods, ribbons, and so forth) arranged in a particular way as well as their growth mechanism. These types of materials not only possess improved properties originating from their building blocks but also solve the problem of nanomaterial agglomeration. Additionally, they find applications in many fields, especially in (bio)-sensoric technology based on Raman spectroscopy.

Experimental: Laser-scanning CARS microscope

The multimodal optical platform (CARS microscope) for performing Raman, SERS and CARS spectroscopy is shown in Fig.1.

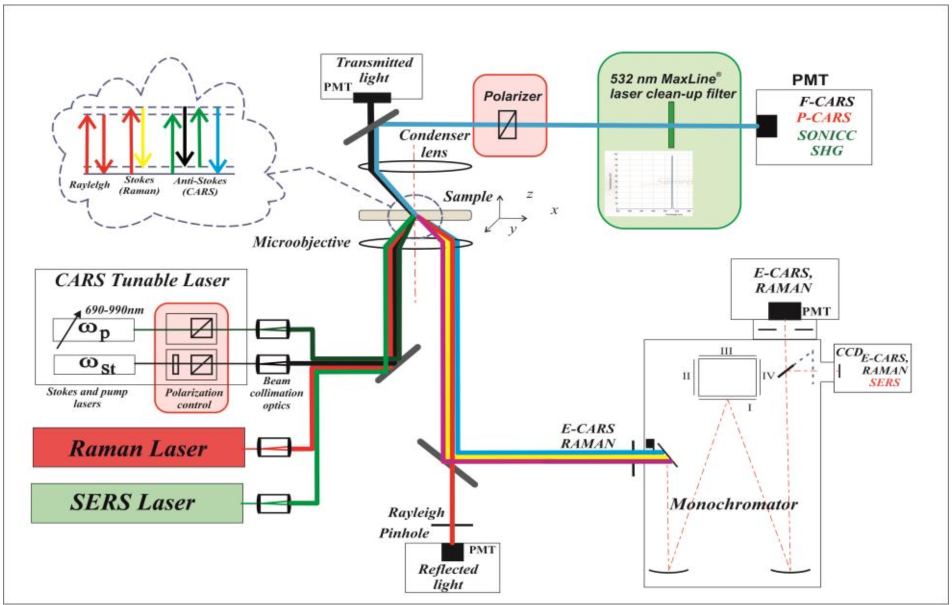

Fig. 1 The layout of the multimodal optical platform: “CARS” microscope

In the given CARS microscope a diod-pump Nd:YVO4 picosecond laser is used as a source of the Stokes wave; it has the wave length of 1064 nm, pulse duration of 7 ps and output power of 5W at the pulse repetition rate of 85 MHz. Only a small portion of radiation was directed to the microscope, the main part of radiation was used for the second harmonic intracavity generation to be applied for the synchronous pumping of the optical parametric oscillator (SOPO). That provided generation of picosecond pulses tunable from 690 nm to 990 nm, with pulse duration of 6 ps and output power up to 0.3W at the repetition rate of 85 MHz.
The microscope is also equipped with a system of collimators, dichroic mirrors and filters whose installment and change is done automatically on PC commands. The microscope is equipped with 6 independent registration channels, two in the forward direction and four in the backward direction.

Fig.2 General view of the CARS microscope

For the SERS measurements, along with the He-Ne laser (633nm), a diode laser generating green light at 532nm is also installed at the optical platform (Fig.2).

The measurement procedure

The potential participant (student) will be acquainted with the whole circle of the measurement procedure consisting of: spectra calibration, laser line alignment, choice of the optical filters and microobjective, sample preparation, scan of the samples and detecting of the Raman and SERS spectra. An example of SERS spectra of rhodamine 6G dye is shown in Fig.3.

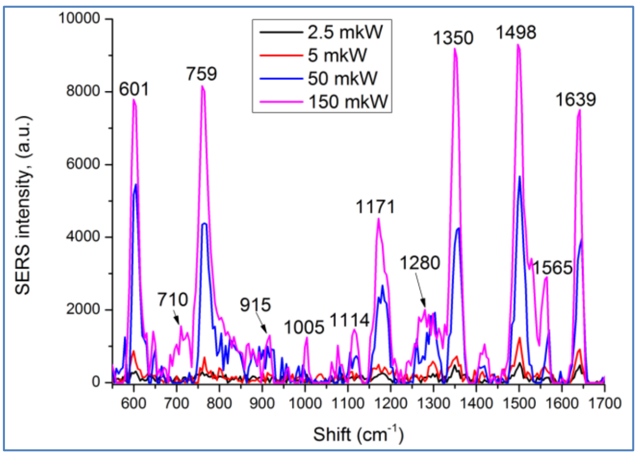

Fig.3 SERS spectrum of R6G 10-6 M excited by the green laser with various powers: 150 μW, 100 μW, 50 μW, 5μW and 2.5 μW

Presentation of results

The results are supposed to be presented in the text format including introduction, obtained results, their description and discussion, as well as (desirable) in Power point format. The knowledge of ORIGIN and Power Point software packages for data processing and presentation is obligatory.

Proposed literature

Jiang et al., "Single-molecule Raman spectroscopy at the junctions of large Ag nanocrystals", J. Phys. Chem. B **107**, 9964–9972 (2003).

M. Futamata, "Single molecule sensitivity in SERS: importance of junction of adjacent Ag nanoparticles", Faraday Discuss **132**, 45-61 (2006).

V. Sivakov, "Silver nanostructures formation in porous Si/SiO_2 matrix", J. of Crystal Growth **400**, 21-26 (2014).

A. Krogh, B. Larsson, G. von Heijne, EL. Sonnhammer, "Predicting transmembrane protein topology with a hidden Markov model: application to complete genomes", J Mol Biol **305**, 567–580 (2001).

J.E. Morgan et al., "Structure changes upon deprotonation of the proton release group in the bacteriorhodopsin photocycle", Biophys J **103**, 444–452 (2012).

R. F. Kubin and A. N. Fletcher, "Fluorescence quantum yields of some rhodamine dyes", J. Luminescence **27,** 455–462 (1982).

Number of students: 1

The project supervisor

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