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Editorial

Special issue on surface-enhanced Raman spectroscopy

Guest editors

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Although Raman scattering spectroscopy was theorized [1] and demonstrated [2] in the late 1920s, its inherent molecular cross-sections, and the lack of appropriate stable sources and optics, hindered its application until the 1960s. During these years the development of resonance Raman [3], which added up to five orders of magnitude intensification to the Raman signal, led to the rebirth of the technique. Following intensified research in the field, in 1974, Fleischnmann *et al* discovered, by accident, an anomalous intensification of the Raman signal when studying the interaction of pyridine with a silver electrode [4]. These authors interpreted the effect as a local increase of the surface concentration of the analyte due to the increase of the surface area of the electrode from its deterioration as a consequence of the consecutive reduction–oxidation cycles. Consequently, the physical effect was incorrectly named surface-enhanced Raman scattering (SERS) spectroscopy.

In 1977 two different key manuscripts, by Jeanmaire and Van Duyne [5] and Albretch and Creighton [6], reported the SERS as a pure electromagnetic effect. In 1980 Otto reported the effect of the charge transfer and the resonance at the surface, the so called chemical effects, on the intensification of the SERS signal [7]. In 1983/84 the surface selection rules were developed independently by Creighton [8] and Moskovits and Suh [9]. Despite these advances, reported by Moskovits in one of the most influential reviews in SERS [10], the research and use of this technique remained mostly confined to academic levels until 1997. During this year two different papers demonstrated the capability of SERS for the detection of single molecules [11, 12]. This fact not only fueled basic research in the field but also in close areas such as nanofabrication, optic theory and the development of applications in biology, medicine, environmental sciences or catalysis. Thus, today an extraordinary effort led by a myriad of research groups is performed to transform SERS into a real live tool, especially in field of biosciences.

This special issue contains 23 papers which envision enlightening the field of SERS from the pure theoretical basics and nanomaterial fabrication to the final development of applications. The issue begins with two reviews summarizing the effects of nanogaps on the SERS intensity of the target probes [13] and the use of SERS encoded particles as contrast agents for optical bioimaging [14]. This collection of papers also contains 21 research articles related to a variety of topics. First, the formal theoretical basis of the effects of multipole surface plasmon resonances on the SERS signal is discussed in a short note [15]. Also, the use of the powerful and well-stablished static DFT methods for the assignment of the vibrational modes are compared with the state-of-the-art time-dependent DFT approaches [16]. Next, some examples are included for the use of SERS as a characterization tool for plasmonic materials [17, 18] and the effects of the polarized light [19] on the resulting signal. The increase of SERS efficiency by the generation of the plasmonic intercouplings, known as hot spots, [20] and some of their methods of preparation are reported for gold nanoparticle monolayer films [21, 22], gold nanorods [23] or discrete plasmonic microparticles [24]. Regarding the preparation of the plasmonic materials for SERS, here we include examples of gold nanostars [25], hybrid magnetic plasmonic particles [26], hybrid polymer nanoparticle films [27] and silica coated plasmonic films [28] and particles [29]. Finally, the potential of SERS to solve real life applications is illustrated through monitoring of the molecular dynamics of a chromophore [30]; the ultrasensitive detection of the chemotherapeutic agent paclitaxel [31], glucose [32] or DNA [33] and their modifications [34]; and the 3D intracellular monitoring of the transportation of nanoparticles in the cytosol [35].

In summary, we hope this collection of articles will stimulate innovative new research in this growing field of SERS by showcasing new advances in characterization and fabrication techniques and applications such as the ultrasensitive detection of analytes, monitoring of complex biological systems or the study of the dynamics of molecules.

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