Efficient Combination of Interference and Plasmon Resonance Raman Amplification by Optimized Heterostructures for Optical microscopy and Molecule Detection

Leo Alvarez-Fraga[1], Esteban Climent-Pascual[1], Montserrat Aguilar-Pujol[1], Rafael Ramírez-Jiménez[2], Félix Jiménez-Villacorta[1], Carlos Prieto[1] and **Alicia de Andrés**[1*]

[1] *Instituto de Ciencia de Materiales de Madrid, Consejo Superior de Investigaciones Científicas. Cantoblanco 28049 Madrid, Spain.* * ada@icmm.csic.es

[2] *Departamento de Física, Escuela Politécnica Superior, Universidad Carlos III de Madrid, Avenida Universidad 30, Leganés, 28911 Madrid, Spain*

The detection, identification and quantification of different types of molecules and the optical imaging of, for example, cellular processes are important challenges. The enhancement provided by electric field amplification due to localized plasmons of metallic nanoparticles, called SERS (surface enhanced Raman scattering) is the most efficient process however, the design of amplification platforms for the detection and imaging of extremely diluted and/or complex materials still requires further research and development to get cheap, reliable, reproducible and stable over time systems that can be easily reused several times. Among the different mechanisms for Raman intensity amplification, the interference process has been scarcely investigated. Here we present how interference enhanced Raman scattering (IERS) in adequately designed heterostructures can provide amplification factors relevant both for detection and imaging. We report how interference enhancement substrates have to be designed to maximize their efficiency and how it is possible to combine SERS and IERS effects. The IERS platforms are demonstrated to improve significantly the quality of white light images of graphene and are foreseen to be adequate to reveal the morphology of ultrathin films and of biological material. We use a transfer matrix method to calculate the propagation of light through the heterostructure (reflecting layer/dielectric layer/ graphene) [1] for a large set of materials in order to obtain the general trends of Raman interference process and to optimize the effect in view of its application. Graphene is used here as the ideal material to reveal the amplification power of the tested platform and as the appropriate substrate for the deposition of organic molecules. We have designed and fabricated optimized heterostructures for IERS which combined with nanostructured silver films demonstrate the combined IERS + SERS amplification.

References

[1] R. Ramírez-Jiménez, L. Álvarez-Fraga, F. Jimenez-Villacorta, E. Climent-Pascual, C. Prieto, A. de Andrés, Interference enhanced Raman effect in graphene bubbles, Carbon 105 (2016) 556