Magnetically-responsive nanophotonics with iron-doped silver nanoparticles

Nanostructures play an important role in photonics, thanks to the wide range of active and passive optical effects they can generate. For instance, silver (Ag) nanoparticles (NPs) are renowned for their plasmonic properties exploitable for quenching or amplification of luminescence from nearby fluorophores, for colorimetric and spectroscopic sensing of analytes, and, last but not least, for the enhancement of Raman scattering from adsorbed organic molecules, according to the popular surface enhanced Raman scattering (SERS) effect which theoretically permits sensitivities down to the single molecule level.

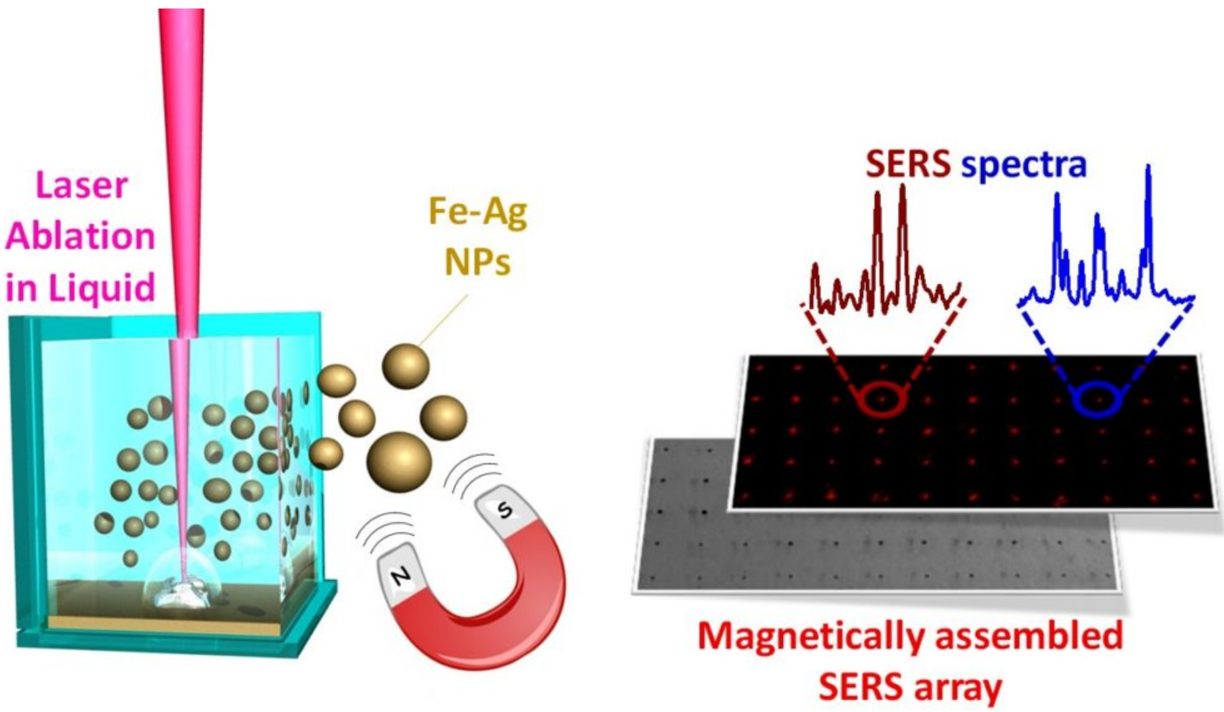

Fig. 1.

Typically, these phenomena are observed by dispersing the Ag NPs in a liquid solution, or by fabricating the Ag nanostructures on a substrate. However, in the first case the optical effects are “distributed” over all the liquid volume, with the consequent dilution of signal intensity; in the second case, time-consuming and costly fabrication methods are generally required, which is a problem for widespread application of Ag NPs based photonic devices in real life.

A recent study demonstrated that coupling of optical and magnetic properties in each single Ag NP is useful to improve photonic performances in liquid phase and lead to simple procedures for the fabrication of Ag-based photonic substrates. The simplest way to confer magnetism to silver NPs is doping their lattice with a magnetic element such as iron. However, the introduction of iron atoms in the crystalline lattice of silver is not easy at all, because of unfavourable thermodynamics to the formation of alloys between the two metals, even when Fe is very diluted.

To solve this problem, an innovative approach was used, based on laser ablation of a bimetallic Fe-Ag target immersed in liquid environment. With laser ablation synthesis in solution (LASiS), NPs form on a time scale of less than a microsecond, that is ideal for freezing Fe atoms in the Ag matrix.

Fe-doped Ag NPs obtained by LASiS are capable of magnetic assembly over extended arrays, with geometry defined from the shape of the externally applied magnetic field. In this way, magnetically assembled and recoverable Fe-Ag NPs arrays were easily achieved, and used for repeated SERS analysis of different samples. Reversible magnetic focusing is possible also when the Fe-Ag NPs are dispersed in a liquid, to obtain amplified signals thanks to the concentration of the magnetic-plasmonic nanostructures in a small volume.

This research can be of inspiration for the realization of various self-assembled and reconfigurable magnetic-photonic nanodevices. Besides, following the same LASiS approach, it was demonstrated that other solid solutions of immiscible elements can be obtained, such as iron and gold, with interesting opportunities for nanomedicine, information storage and catalysis.

Vincenzo Amendola
University of Padua, Department of Chemical Sciences, Padua, Italy

Publication

Magnetically Assembled SERS Substrates Composed of Iron-Silver Nanoparticles Obtained by Laser Ablation in Liquid.
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