Enhanced optical functionalities with Au-based nanostructures

T. Cesca, B. Kalinic, C. Maurizio, N. Michieli, V. Russo, C. Scian, G. Mattei*
University of Padova, Dept. of Physics and Astronomy, NanoStructures Group, via Marzolo 8, Padova (Italy)

A. Trapananti
CNR-IOM c/o European Synchrotron Radiation Facility, B.P. 220, Grenoble (France)

Au-based nanostructures have been the object of strong interest from the scientific community in the last decade for their linear and nonlinear optical properties. Controlling the size, shape, composition and degree of interaction one can achieve innovative or hybrid functionalities like the magnetoplasmonic ones, when for instance Au is coupled to a magnetic metal in the nanostructures. These enhanced functionalities can be exploited in different fields of application, spanning from nanophotonics, optical telecommunications, nonlinear optics and molecular sensing.
In this talk we will review some of the results obtained by our group on two classes of Au-based nanostructures: (i) pre-plasmonic sub-nanometric clusters and (ii) fully-plasmonic ordered arrays of nanostructures.
Regarding type (i), recently our group demonstrated that Au_N and $(Au\text{-}Ag)_N$ clusters (with N=5-20 atoms) are able to boost the photoluminescence of Er^{3+} ions located in close proximity by a non-resonant, non-radiative broad-band pumping scheme, with a resulting enhancement of their effective excitation cross section by 2-3 orders of magnitude with respect to the same system without metal clusters [1,2]. This has important technological entailments in optoelectronics where many research efforts are being done in these years to increase the small cross-section for Er excitation.
Finally, we investigated fully-plasmonic nanostructures – type (ii) - for applications in bio-sensing [3] and nonlinear optics [4]. We will discuss two different ordered nanostructures obtained by the nanosphere lithography technique: NanoPrism Arrays (NPA) and Semi-NanoShell Arrays (SNSA).

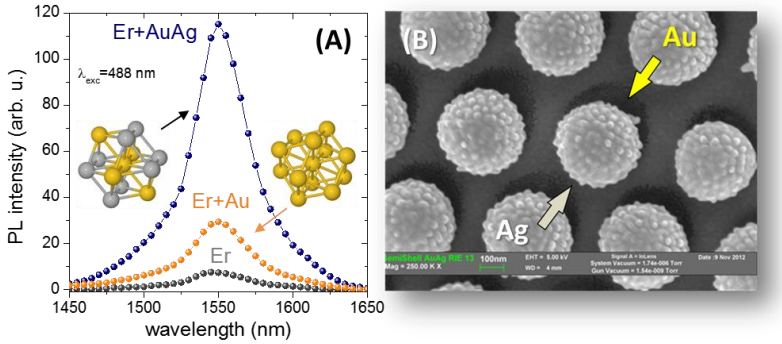

Fig.1: (A) room temperature PL enhancement from Er^{3+} ions in silica upon interaction with AuAg or Au sub-nanometric clusters; (B) Au-Ag Semi-NanoShell Arrays (SNSA)

*giovanni.mattei@unipd.it

[1] Cesca, T., et al, Interatomic Coupling of Au Molecular Clusters and Er $^{3+}$ Ions in Silica. *ACS Photonics* **2015**, *2*, 96–104.
[2] Cesca, T., et al., Near-Infrared Room Temperature Luminescence of Few-Atom Au Aggregates in Silica: A Path for the Energy-Transfer to Er $^{3+}$ Ions. *Nanoscale* **2014**, *6*, 1716–1724.
[3] Michieli, N., et al., Optimal Geometric Parameters of Ordered Arrays of Nanoprisms for Enhanced Sensitivity in Localized Plasmon Based Sensors. *Biosensors and Bioelectronics* **2015**, *65*, 346–353.
[4] Cesca, T., et.al. Nonlinear Absorption Tuning by Composition Control in Bimetallic Plasmonic Nanoprism Arrays. *Nanoscale* **2015**, *7*, 12411–12418.