# A chemical route to design plasmonic-semiconductor nanomaterials heterojunction for photocatalysis applications

Hybrid heterojunctions composed of semiconductors and metallic nanostructures have perceived as a sustainable technology, due to their perfect effectiveness in improving, renovating, and enriching the properties of the integrated components. The cooperative coupling results in the variation of the system's functional properties, by which the metal-generated surface plasmon resonance can enhance the charge separation, light absorption, as well as luminescence of the semiconductor. This phenomenon enables strong interactions with other photonic elements such as quantum emitters. These multifaceted functionalities arise from the synergic exciton-plasmon interaction between the linked units. Thereby, hybrid systems become suitable for various applications including: solar energy conversion, optoelectronic devices, light-emitting diodes (LED), photocatalysis, biomedical sensing, etc.

Au-ZnO nanostructures have received growing interest in these applications, where the deposition of gold nanoparticles (GNPs) promotes the system's response towards the visible region of the light spectrum through their surface plasmon resonance (SPR). Based on a specific size and purity of ZnO nanostructures, as well as the GNPs, and a definite inter-distance between the nanoparticles, the properties of the ZnO nanostructures are varied, especially the photoemission and photocatalytic ones.

In this context, we have focused on the construction of size-tunable ZnO nanocrystals (NCs), then incorporated into GNPs solutions using a simple chemical way. This work is divided into two parts: the first is to perform synthesis of pure ZnO NCs having excellent UV photoluminescence. This was achieved through a low-temperature aqueous hydrothermal synthesis, resulting in rough and amorphous structures. The synthesis was followed by a post-thermal treatment in order to crystallize the obtained particles. The synthesis was followed by structural and optical studies (SEM, TEM, XRD, photoluminescence). The photocatalytic activities of ZnO NCs were studied through tailoring their ability to degrade the methylene blue (MB) dye. In addition, the relationship between ZnO structures, luminescence, and photocatalytic properties was explored in details.

In the second step, the obtained ZnO NCs were added to gold nanoparticles of various sizes and volume fractions. The effective role of GNPs concerning their size, amount, and their capping molecule on the photoemission of the ZnO nanostructures was emphasized through the charge and/or energy transfer between the constituents in the hybrid system. In the same way, the systems photocatalytic activities were examined after coupling ZnO to GNPs.

Further advancement in the integration of the ZnO NCs into PMMA polymer layers was featured in order to obtain large area template of homogenous ZnO properties. The PMMA-assembled ZnO nanoparticles could be promising substrates as catalysts for growing ZnO nanowires, metallic nanoparticles and hybrid nanomaterials.