The growing development of technology of functional materials focuses on designing their dimensions below 100 nm (10^{-9} m). Such a nanomaterial often exhibits different physicochemical properties compared to the sizes visible to the naked eye. In addition, its functionality can be modified by combining several materials with different properties and are called hybrid nanomaterials. This approach allows for obtaining advanced heterostructures with many functionalities resulting from unusual combinations of the components.

This project focuses on semiconductor-plasmonic hybrids that effectively enhance light trapping and conversion. Thanks to the synergistic combination of unique photoelectric properties and enormous amplification of the electromagnetic field, metal-semiconductor heterostructures enable diverse and innovative applications for the rational design of photovoltaic and catalytic devices or ultrasensitive sensors of chemical and biological substances. The key goal of the project is to investigate the processes responsible for these properties by recording the molecular signal generated at the semiconductor-plasmonic particle interface. For this purpose, field-enhanced spectroscopy techniques with the detection of inelastic light scattering will be used, i.e. surface-enhanced (SERS), photoinduced (PIERS), and tip-enhanced (TERS) Raman spectroscopy. Each of them provides a unique way of how the produced charge carriers migrate between the components of the hybrid nanomaterial and how this transport affects the magnitude and durability of a given function. These observations at the level of single molecules and the interface of both components of the nanomaterial will revolutionize our ability to understand the molecular world and manipulate materials to achieve their efficient multifunctionality in photo-induced reactions or optical sensors.