Summary

The doctoral thesis was dedicated to the so-called nonlocal photoluminescence processes, in which the excitation of individual nanoemitters is achieved using surface plasmon polaritons propagating in a metallic nanoparticle. The experimental characterization of such processes required the construction of a highly sensitive confocal microscope of sensitivity sufficient for single nanoemitters detection. The experiment was realized using monocrystalline silver nanowires and rare-earths doped up-conversion nanocrystals.

In one of the initial experiments, the nanostructure consisting of silver nanowires covered with randomly positioned nanocrystals was used, and the influence of the nanowire-nanocrystal distance on the efficiency of the metal-enhanced up-conversion process was examined. For this purpose, a technique using a PVA layer (separator) to define the distance between these nano-objects was developed. This enabled, among other things, the finding of the optimal distance between the nanocrystals and nanowires, allowing for the activation of polaritons by excited nanocrystals.

A detailed examination of this phenomenon required the preparation of a unique nanostructure featuring a precise arrangement of nanoparticles. For this purpose, a new technique was developed for precisely depositing extremely small volumes of nanomaterials (fractions of attoliters) in the form of droplets directly onto the sample surface. This allowed for the preparation of a unique nanostructure called a hybrid matchstick, in which a small population of nanocrystals was precisely placed at one end of the nanowire.

For this nanostructure, remote photoluminescence activation and detection processes using plasmonic excitations propagating there and back in the nanowire were investigated. Moreover, the influence of the nanowire diameter and the laser field composition on the activation efficiency of such a process was described. It has been shown that in the presence of the nanowire, the laser field components interfere, leading to the intensification of interaction with the nanowire. A simple model describing the nanowire's modification of the laser field was also proposed.

Finally, the practical application of the nanostructure with hybrid matchstick geometry was demonstrated by measuring the attenuation of a single silver nanowire. For this purpose, a technique for precisely modifying the length of the nanowire using laser ablation was developed. Careful analysis of the light intensity transmitted through the gradually shortened nanowire allowed the nanowire propagation losses to be estimated.