Aim of the project

The aim of the project is to obtain and characterize active metamaterials composed of organized chains of selected metal (Cu, Au, Fe) and magnetic oxides (Fe_xO_y) nanoparticles which exhibit functional magneto-plasmon properties. Metamaterial is a material which are intentionally engineered in the laboratory, which properties coming from and the distribution of nanoparticles. The distribution of those nanoparticles can be controlled by the self-organisation process on the selected monocrystalline substrates. The optical and magnetic properties are emergent from the distance between particles and their ordering. The direct result of this project activities will be the new knowledge about enhancement of local surface plasmon resonance, which is a result of an oscillation of conduction electrons, in two component metamaterials. The occurrence of this resonance and a its understanding are crucial for their application in optoelectronics.

Reasons for undertaking a research subject and a description of basic research

The novel functional materials, which will be applied as the part of the future devices have to fulfil several requirements among which the most important are efficiency, repeatability and stability, which are directly connected with the material they are built of. Therefore, it is important to know the properties of those materials and their origin. That approach circumvent the problems, which makes practical application of those materials difficult. Recently, extensive studies have shown that combining two different nanostructured materials can improve their magneto-plasmonic properties. It is foreseen that nanoparticles composed of two different materials being the subject of this project contribute and synergetic increase functional magneto-plasmonic properties.

Plasmonic materials are usually metallic nanostructures, which due to the ability to localized electromagnetic wave in small area cause appearance of surface plasmons. Plasmons are collective oscillations of the electron gas density. In those type of materials localized surface plasmon resonance can occurred. Localized surface plasmon resonance (LSPR) is an physical phenomena generated by light when it interacts with conductive nanoparticles that are smaller than the incident wavelength. The resonance condition is fullfield when the frequency of incident photons matches the natural frequency of surface electrons oscillating. Control of LSPR can be provided by the change of resonant frequency, which strongly depends on the composition, size, geometry and separation distance of nanoparticles. The possibility to active control of the optical and electronic properties of material is crucial for future technological applications. An active optical tenability of nanoparticles can be achieved by applying an external magnetic field. Therefore, it is planned to use the magnetic material for deposition of nanoparticles will allows for control of electrical and optical properties.

It is planned to investigated the influence of ordering and composition of nanoparticles and core-shell nanoparticles, being composed of plasmonic materials: Cu, Au and magnetic materials: Fe, Fe_xO_y. Nanoparticles will be deposited using cluster source which combines a magnetron sputtering with an Inert Gas Condensation technique. In the first step the atoms of the target are ejected due to bombardment of argon ions and then condensate in aggregation zone, where evaporated atoms collide with the gas atoms within the chamber, thus lose kinetic energy and create nanoparticles. Cluster source allows to simultaneous deposition and formation of composite nanoparticles from three magnetron sources as well as deposit core-shell nanoparticles using separate additional magnetron source.

It is planned to form the scientific research team of experts, which will carry out advanced studies in order to determine structure, morphology, optical, electrical and magnetic properties of obtained metamaterials. The results of the project shall significantly expand the knowledge on synthesis routes and optimum structure of new nanoparticles exhibiting magnetic and plasmonic properties. The original results of this scientific project can be a base for future industrial applications and applied research.