1. The project objective

The main objective of the project is to obtain and characterize novel types of nanocomposites, built of the metal nanoparticles embedded inside of the hematite matrix. Those granular materials are obtained by simultaneous or sequential sputtering of target materials (such as hematite and selected metals), which are placed inside of the deposition chamber. After the post-growth thermal annealing the segregation into two phases is occurring – the metal atoms agglomerate and form the nanograins dispersed inside of the matrix, which is built of the second material. By adjusting the conditions of fabrication process, the chemical composition and the materials morphology can be tuned. The physical properties of such system are strongly correlated to the size of the nanograins and their distribution in the material. Especially it is visible during electrical transport - the strong influence of external factors, such as magnetic field, presence of some gases has a crucial impact on conductivity, which can be even changed by few orders of magnitude.

2. The basic research to be carried out

The proposed research is focused on the fabrication process of nanocomposites, called also granular metals, using reactive ion sputtering. The influence of deposition conditions on the material structure will be studied in details. The set of obtained samples, selected based on the preliminary electrical and magnetic measurements, will be then further investigated with respect to their electrical and magnetic properties, measured by the dedicated apparatus as a function of temperature or external magnetic field. The optical characteristics will be done by spectrophotometry and measurement of photocurrent. At this stage we will be able to provide an information if the material is responsive to magnetic field or certain light wavelength.

3. Motivation

The motivation of the proposed project is the unique set of physical properties of granular metals, not sill well understood, which are different to behaviors observed in case of standard metals or semiconductors. The strong dependence of conductivity on temperature or external magnetic field or light source makes them very promising materials in various sensing application. The first tests on those samples (performed in collaboration with dr Artur Rydosz at AGH) showed an excellent sensing characteristics.
The sputtered films of hematite also exhibit very interesting magnetic properties. We have shown that by modifying the deposition conditions their magnetic response can be similar to the ones observed in superparamagnetic materials or materials with a perpendicular anisotropy.
After the post-growth thermal annealing the nanocomosite films are very stable in time, which allows for planning experiments at large research facilities with a use of synchrotron radiation.