Improving the conductivity of printed patterns by optimizing the synthesis process and physicochemical properties of metal nanoparticles..

The research objectives

In recent years, metal nanoparticles have generated considerable interest because of their unique properties, which are interesting not only from the scientific point of view but also because of the possibility of their use in many branches of industry. One of the applications of metal nanoparticles is conductive inks that can be used for the fabrication of "printed" electronic devices. **Therefore, the main objective of the project is to obtain and use metal nanoparticles as functional components of the inks to improve the conductive properties of printed tracks.** Silver nanoparticles have been the most commonly used so far as a component of conductive inks. Although this kind of nanoparticles have obvious advantages such as high conductivity and stability against the oxidation process, their high price limits their large-scale industrial application. **Thus, an important aspect of the project is the replacement of silver nanoparticles with a component of ink that has still good conductivity, while its price is much lower than silver.** The ideal candidates are copper (Cu), nickel (Ni), and tin (Sn) nanoparticles. Therefore, the planned research assumes their using as functional components of the conductive inks formulation. However, the disadvantage of these nanoparticles is their rapid oxidation in an atmospheric environment, **therefore the important goal of the project is to create a protective layer on their surface in the form of silver (Ag) or gold (Au), which will result in core-shell nanoparticles (where core - Cu, Ni or Sn, shell - Ag, Au).** Finally**, the resulting bimetallic core-shell nanoparticles will be used for inks preparation, which requires the optimization of their wetting, spreading, and adhesive properties to obtain high quality conductive, printed circuits.**

Research carried out in the project

In the first stage of the planned research, metal nanoparticles such as nickel, copper, or tin will be obtained and their physicochemical properties (size, shape, and aggregation level) will be investigated. Then, these nanoparticles will be surrounded by silver or gold layers to obtain "core-shell" nanoparticles. The formation of a thin silver/gold layer on the surface of nonnoble metal NPs (Cu, Ni, Sn) will provide their protection against the oxidation process. In the next step, core-shell nanoparticles will be used for the preparation of conductive ink formulation for the various methods of printing process (screen printing, inkjet printing), which require the optimization of ink properties as well as a condition of printing methods to obtain a high quality printed pattern, which results in the high conductivity of the metallic coating. To transform nonconductive tracks to the conductive one the sintering process will be performed, which is usually required because of the presence of the polymeric stabilizer, which causes that the resistivity is too high to be practical of importance. The direct contact between metal NPs within the ink layer on a substrate to obtain electrical patterns with high conductivity will be achieved by using a thermal or chemical method of sintering.

Reasons to take up the subject matter

The planned research is directly related to the field of nanotechnology, which in recent years has had a huge impact on many areas of human life. The subject of research is primarily important from the point of "printed" electronic devices, which can be produced fast, simply, and effectively by using the methods (screen printing, inkjet printing), which are proposed in the project. **Therefore, the main reason for carrying out the planned research is to obtain the results that will allow formulating scientific guidelines for further work on the production of innovative "printed" electrical circuits.** Besides, carrying out the research presented in the project is motivated by the opportunity to improve the existing methods of preparation of conductive inks based on metal nanoparticles. Improving their wetting properties can contribute to the generation of electrical devices characterized by durability, efficiency, and reliability. The research planned in the project also provides the process of obtaining low-cost (which is important from an economic point of view) conductive circuits with the desired conductive properties.