**Objective of the project**

The main goal of the project is to design new class of materials - hierarchically porous and anisotropic (Janus_like) semiconductors based on copper ($Cu_{2-x}O$, $Cu_{2-x}S$) and tin ($SnO_{2-x}$, $SnS_{2-x}$) compounds) with enhanced adsorptive capacity with gas sensors and environmental protection as target applications.

The recognition that anisotropy is a powerful tool for engineering the assembly of particular targeted forms has brought new excitement to the field. By offering a combination of certain optical, magnetic, and catalytic properties in one particle, and owing to the fact that their properties can easily be modified by varying the materials, domain sizes, and morphology, inorganic hybrid materials have become increasingly popular. The design and fabrication of particles with different geometry and anisotropic material composition have drawn great attention in recent years. The following challenges are identified in the project: achieving an understanding of the correlation between microstructure and physicochemical properties, and characterization of the adsorptive capacity.

**Reason for choosing the research topic**

Solid surfaces are characterized by active, energy-rich sites that are able to interact with solutes in the electrolyte due to their specific electronic and spatial properties. Since adsorption is a surface process, specific surface area (surface development) is a key parameter of applied materials. However an increase in specific surface area affects the surface energy, which affects adsorptive capacity.

Over the past three decades, significant progress has been made in the field of materials science. This unbelievable revolution has led to a spectacular variety of building blocks of different shapes, compositions and functionalities. The development of new biophysicochemical methods used to obtain anisotropic structures should provide a powerful arsenal for the synthesis of new particulate architectures. However the impact of the ceramics' (semiconductors') surface anisotropy on their adsorptive properties has not been elucidated. The main objectives of the presented project is to design a new class of materials - hierarchically porous and anisotropic particles, capable of enhanced adsorption, intended applications as gas sensors or molecules sorbents (e.g. in environmental protection).

**Research to be carried out**

We expect that the obtained results will contribute to the development of a new class of next-generation devices used for detection of reducing and oxidizing gas as well as environmental protection.

The characterization of will include the analysis of: crystal structure phase composition (XRD, Raman and FTIR spectroscopy), microstructure (SEM, HR-TEM), and thermal stability (DTA/TG). A crucial aspect of the project is the study of the surface properties of the obtained materials, which includes measurements of specific surface area (BET nitrogen adsorption isotherms), zeta potential (potentiometric measurements), and hydrodynamic diameter (DLS measurements). The adsorption/desorption process is associated with a surface charge (double-layer) at the material/electrolyte (gaseous or liquid) interface. Knowledge of dynamic changes of the surface charge will contribute to the determination of its critical value, at which there is no charge accumulation. The optical properties will be studied using a UV-Vis spectrophotometer equipped with an integrating sphere. Based on the obtained results the values of the optical band gap (Eg) will be determined by applying the Kubelka-Munk function. Moreover, using this fitting verification the type of optical transitions (direct or indirect allowed) can be established. Impedance spectroscopy (EIS) will not only enable the conductivity of the materials to be measurement, but it will also allow the separation of boundary and grains conductivity. The electron work function for the semiconductor surface will be analyzed by a Kelvin probe. The obtained results will contribute to the understanding of the electronic structure and conductivity type: n or p. Adsorption properties will be determined by means of (I) adsorption/desorption studies, (II) gas detection analysis – detection of three different gases: reducing (hydrogen), oxidizing (oxygen) and mixed reducing/oxidizing (ammonia) and (III) gas/liquid adsorption of methane and/or methylene blue.

The principal investigator plans to create a research group composed of experts, who will conduct a comprehensive study to determine the structure, morphology, optical, electrical and adsorptive properties of obtained hierarchically porous and anisotropic structures based on copper and tin compounds. We expect that the obtained results will contribute to the development of a new class of next-generation devices used for detection of reducing and oxidizing gas as well as environmental protection.