The main objective of this project is to expand the current state of knowledge about so-called high-entropy oxides (HEOx) in the aspect of the development of effectively-working anode materials for Li-ion batteries. The general idea of HEOx is to stabilize simple solid solution structures by the influence of high configurational entropy. It can be accomplished by mixing several components (at least five) in equimolar or near-equimolar proportions. This approach to materials' design is completely different from the conventional one and allows for obtaining extraordinary properties. As for today, only one composition from a large group of HEOx materials has been considered as an anode for Li-ion batteries. Moreover, it has been documented that the electrochemical performance of cells largely depends on the morphology (shape and size) of the synthesized active material. So far, only one research group has studied the optimization of this parameter for the high-entropy anode. It is expected that comprehensive characterization of structure and physicochemical properties of spinel-type HEOx will enable to select the best candidate anode material, while employment of advanced preparation methods will allow obtaining the active compound with desired nano- and microstructure. With the combined optimization of chemical composition and morphology, the developed anodes will deliver exceptional electrochemical performance. Consequently, in this proposal three fundamental aspects will be joined to achieve the main objective: 1) spinel-type oxides shall ensure high theoretical capacity for the Li-ion battery; 2) a high-entropy approach will enable to obtain novel HEOx compositions through stabilization of the crystal structure, which should be beneficial concerning electrochemical performance; 3) advanced synthesis methods will allow obtaining desired morphology of the active HEOx compounds, which is needed in order to optimize performance of the developed anode materials.

Nowadays, energy demand significantly increases every year all over the world. It is relevant to develop modern technologies for obtaining electricity as well as electrical systems in order to store received energy. Currently, one of the top solutions are Li-ion batteries. The best prove of their influence on today's technology is the Noble Prize in Chemistry 2019 awarded "for the development of lithium-ion batteries". However, there is still an urgent need to design and manufacture Li-ion cells with higher capacity, energy density, improved safety and extended lifespan. Classical commercial Li-ion technology, based on lithium metal oxide cathode, *e.g.* $LiNi_{1-x-y}Co_xMn_yO_2$, and graphite anode, has already reached its theoretical limits. Among alternative anode materials, nanostructured metal oxides have been proposed. While a high capacity could be obtained for various studied compounds, many major problems (especially significant capacity fade during the battery work) still have not been solved. The materials investigated in the proposed project - high-entropy oxides - are great candidates in order to overcome these limitations.

The research tasks proposed in the project were carefully planned in order to fulfill the presented objectives. The research methodology includes the synthesis of materials by solid state reaction as well as soft-chemical methods. The products will be investigated in terms of chemical composition, structure, microstructure and stability. One of the most important parts of studies will rely on electrical properties measurements in order to select the best possible compositions. Chosen HEOx will be assembled in cells to establish their electrochemical performance, which will be the crucial stage of the entire work plan. It will allow selecting the most optimal high-entropy anode materials for Li-ion technology. Additionally, in this project, mechanisms occurring at an anode during battery work will be studied. For the most promising compositions, an attempt to transfer these solutions to a larger scale will be made.

The results obtained during conducted preliminary study indicate that the presented work plan is appropriate and allows utilizing proposed anodes assembled in cells in an effective way, leading to the promising electrochemical performance. Since the considered in this proposal scientific problem concerns the first implementation of spinel structured high-entropy oxides as anodes in Li-ion technology, it will open new paths for further improving the performance of HEOx, hence the useful parameters of cells. Realizing planned research will not only greatly increase the current knowledge about high-entropy anode materials, but will also lead toward the progress of the entire Li-ion batteries field.