In the fast-changing world, mankind needs reliable energy sources to achieve economic development goals, improve quality of life, and promote social progress. Conventional fossil fuels such as oil, natural gas, and coal are growing concerns due to environmental issues and the uncertainty of their continuous supply. Renewable energy sources (RES) can ensure energy reliability, but due to the intermittent nature of obtaining energy from RES (e.g., wind, solar energy), infrastructure capable of storing and converting this energy is necessary. Solid Oxide Cells (SOCs) attract attention as efficient technologies for converting the chemical energy of hydrogen-rich fuels into electricity and heat. However, for the full commercialization of SOC technology, the development of new electrode materials is necessary to improve durability and achieve high power and energy density even at reduced temperatures. Due to simplified construction and favorable reversible operation (between fuel cell and electrolyze modes), SOCs with a symmetrical configuration, where the same electrode material is used as both the anode and the cathode, are particularly interesting. Electrode materials in symmetrical SOCs to achieve high conversion efficiency must fulfill many requirements, like high electrocatalytic properties for electrode reactions, mixed ionic-electronic conductivity, compatibility with the electrolyte, as well as structural stability under both anode and cathode conditions. The *in situ* exsolution process is regarded as very beneficial for improving electrode properties and meeting the requirements. Literature data indicate that *in situ* exsolved nanoparticles, due to their anchoring mechanism to the parent oxide, can increase the catalytic activity and stability of the material. Moreover, the reversibility of the exsolution can potentially solve the problem of particle agglomeration, increasing resistance to carbon deposition when the SOC is fueled with cheaper, more widely available hydrocarbons. The influence of exsolution on material properties depends on the type of the exsolved metal alloy. Due to their unique electrocatalytic properties and excellent thermal, chemical, and structural stability, high-entropy metallic alloys, composed of at least five different elements, are considered as excellent catalysts. The properties of high-entropy nanocatalysts are size-dependent. To maintain the benefits of the high-entropy alloys, the nanometric size of the nanocatalysts is necessary. To obtain materials with controlled size and favorable morphology for the electrode layer in SOCs (continuous porosity, high specific surface area), the design of nanofiber electrodes using the electrospinning technique seems to be fully rational.

Considering the necessity to develop electrode materials enhancing SOC parameters, this project focuses on developing functional, high-performance electrode materials from the $Ln_{0.9}(Ba, Sr)_{0.9}(Fe, Mn, Mg, Ti)_{1.8}(Co, Ni, Cu, Pd)_{0.2}O_{6-\delta}$ (Ln = selected lanthanide) system in the form of nanofibers, capable of *in situ* exsolution of high-entropy metallic nanocatalysts.

The project will employ the following strategies for designing electrode materials:

- Introducing at least five metal cations into the B-site sublattice with the ability to be reduced to a metallic state, allowing *in situ* exsolution of high-entropy alloys.
- Cation deficiency in the A-site perovskite sublattice will intensify the *in situ* exsolution process.
- Utilizing the electrospinning method in the synthesis of compounds will ensure morphology control and obtain nanofibrous electrode materials with exsolved nanocatalysts of the desired size.

Achieving the expected results could significantly impact the development of solid-state physical chemistry by understanding the reversible *in situ* exsolution process of high-entropy nanocatalysts under both reducing and oxidizing conditions from materials with controlled morphology. Because of the almost complete lack of published research on *in situ* exsolution of high-entropy alloys from nanofibrous electrode materials for symmetrical SOCs, the project topic seems to be particularly innovative. During the project implementation, an interdisciplinary approach will be utilized, including knowledge from materials engineering, solid-state physical chemistry, and electrochemistry. The application of advanced research methodologies, including diffraction techniques (XRD, HT-XRD, neutron diffraction), electron microscopy (SEM, EDS, TEM), and spectroscopic methods, will allow for the development of basic principles for designing functional, stable electrode materials with controlled morphology and particularly high catalytic activity for their application as high-performance electrode materials for symmetrical SOCs used in energy generation and storage systems.