Due to a constantly growing economy, progress in a field of new technologies and a rising consumption of electricity and heating/cooling needs by individual customers, there is an increasing demand for energy observed worldwide. Also, a decreasing amount of available fossil fuel resources forces us to develop new, more efficient and reliable energy conversion technologies. Solid Oxide Fuel Cells (SOFC), which are electrochemical devices that convert chemical energy of a fuel and an oxidizer directly into electricity and heat, consists of (like all electrochemical cells) three basic elements: anode, cathode (electrodes), and ceramic electrolyte, which separates them. SOFC fuel cells, exhibiting high energy conversion efficiency, are of special interest in emerging hydrogen economy, but also in so called clean coal technologies, in which traditional, fossil fuels are utilized more effectively and in more environmental friendly way. Classic SOFC technology relies on purely oxygen ions conducting (transporting negative charge O^{2-} ions) electrolytes, which are typically ceramic oxides, e.g. yttria-stabilized zirconia, YSZ. This is due to their unsurpassed chemical stability at elevated temperatures (600-1000 °C) in a wide range of gas atmosphere compositions (oxidizing, inert and reducing conditions), as well as because of the high values of oxygen ionic flux. Recently, in order to improve operating parameters of SOFCs and lower their operating temperature (which is beneficial concerning costs and long-term operation), a replacement of the oxygen ion-conducting electrolytes with materials exhibiting hydrogen ions conduction (transporting positive charge H^+ ions) was proposed, and shown to be effective. Proton Ceramic Fuel Cells (PCFC) have additional significant advantages. In classic approach with oxygen-conducting electrolyte, oxidant (usually air) is delivered on the cathode side, and fuel (usually pure hydrogen) is delivered on the anode side, where at the same time water vapor formation occurs (H_2O is a product of the electrode reactions). This leads to a dilution of fuel, which in turn causes reduction in efficiency of cell's work. In the case of proton-conducting electrolyte reactants are delivered in the same way, but the reaction product forms on the cathode side, thus not diluting fuel, which results in an increased fuel conversion efficiency. However, despite of a fast development of proton-conducting electrolytes, it is easy to notice significantly slower progress concerning electrode materials, which are suitable for such the technology.

The aim of this project focuses on development of novel composite-type electrode materials for PCFC fuel cells, which are based on Mo-containing materials exhibiting performance stability in reducing and oxidizing conditions, as well as on understanding of the charge transport in such electrodes. The main idea is based on an interaction between one material with a high proton conductivity, and the other one, exhibiting a high mixed ionic-electronic (MIEC-type) transport in composite-type electrode. In the electrode the protonic component of the conductivity is realized by the same phase, as used in the solid electrolyte (e.g. doped $SrCeO_3$), while the electronic component is ensured by a selected material from $Sr_2Fe_{2-x}Mo_xO_{6-\delta}$ group, having apart from high electrical conductivity in reducing and oxidizing conditions, also good chemical stability, and exhibiting good oxygen ion transport. Because of the crystal structure and chemical composition, the proposed group of Mo-containing materials exhibits unusually high, metallic-type conductivity. In the planned approach, both composite-type electrodes are identical in terms of their chemical composition (creating so called symmetrical fuel cell), which simplifies manufacturing process and limits unwanted chemical reactivity. At the same time, usage of one type of electrode material greatly reduces costs of manufacturing of the cells.

Apart from synthesis of the respective materials and construction of laboratory-scale button-type Proton Ceramic Fuel Cells, tasks of the project are planned in a way to ensure possibility of throughout studies of the electrode processes occurring during operation of such cells. This, in turn, will allow to elucidate character of the anode and cathode reactions, which is of a great scientific importance. Successful accomplishment of the proposed tasks shall have major impact on progress of Solid Oxide Fuel Cell with proton-conducting electrolyte technology in the aspect of increasing of the stable and efficient performance and lowering of the operating temperature of the cells. It is expected that result of the conducted studies will be of a great help for solving materials-related problems of the SOFC technology.