The development of the high-entropy materials, paved new ways in functional materials' design, potentially providing previously impossible combinations of properties, applicable in a wide variety of strategic applications such as the energy-conversion technologies. An area that may especially benefit from such capabilities is solid oxide fuel cells (SOFCs) and solid oxide electrolysis cells (SOECs), which are nowadays widely considered as one of the most promising ways of converting energy, offering excellent efficiency, low pollution level, and versatility in terms of both producing and storing energy. Still, their widespread application is hindered by the number of unresolved issues, with the design of effective, functional, air-electrode materials becoming the main limiting factor. The leading hypothesis of the project is that the application of the high-entropy approach to the design of the air-electrode materials may lead to obtaining combinations of functional, catalytic, and transport properties, which are beyond the characteristics of the conventional systems, making these innovative materials potentially suitable for different types of SOFCs' operation, and granting them with superior qualities to their conventional counterparts. The high entropy approach is based on a very simple principle – instead of utilizing one – two main components, at least five of them are mixed together in equimolar or near-equimolar proportions (Fig. 1). The resulting huge number of interactions between elements often generates completely new properties, on the basis of synergistic effects. Consequently, in the context of solid oxide fuel cell applications, it may enable for bringing together the often conflicting requirements of electrochemical performance and functionality in air electrode materials.

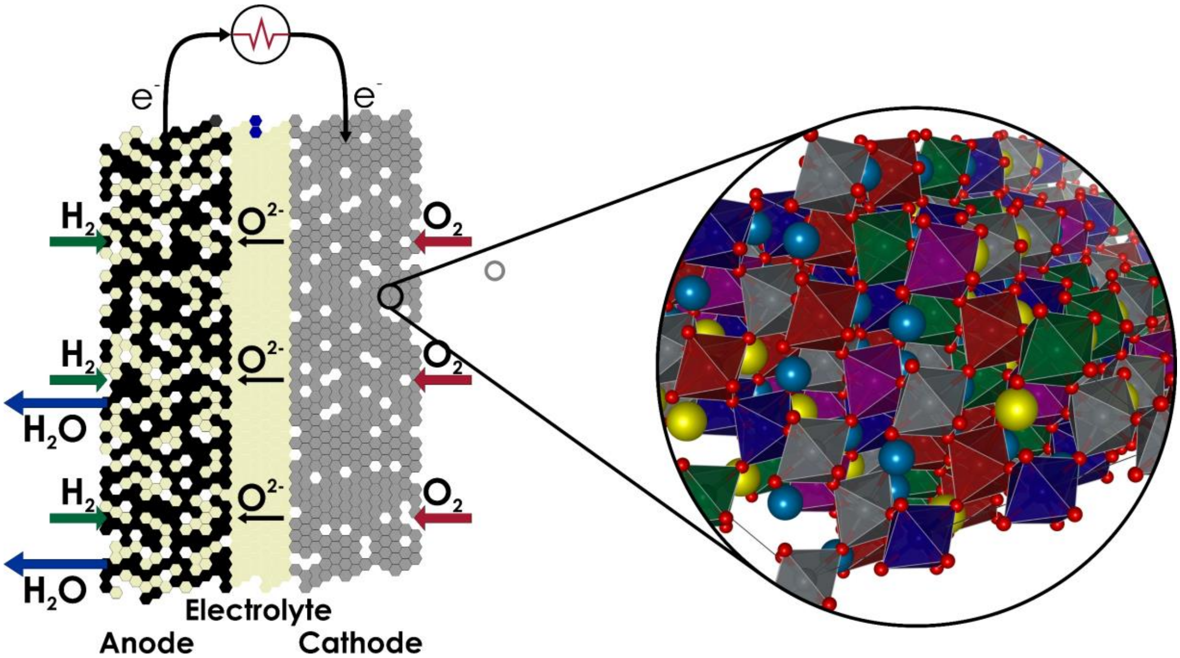

Fig. 1. *Schematic presentation of the fuel cell with high-entropy perovskite air-electrode.*

Unfortunately, as of today very little is known regarding the transport and catalytic properties of HEOx systems, not to mention their performance in the SOFCs and SOECs. Therefore, the main objective of the project is to conduct the very first, comprehensive evaluation of the HEOx potential with regard to fuel cell technology, allowing obtaining highly functional and effective air-electrodes. To achieve this goal, a number of the perovskite-type, high-entropy compositions will be synthesized for the first time, and further subjected to a systematical characterization of their properties. The electrodes based on the most promising composition will be thoroughly optimized and tested using the button-type cells, in both fuel-to-energy and energy-to-fuel modes, allowing establishing the potential performance levels of these materials. The scientific goal of the project will be to utilize the obtained results, and using the bottom-up philosophy, identify the origins of specific compositions' superior performance, bringing in the process an in-depth understanding of their composition-structure-properties relations through an interdisciplinary analysis combining both experimental and theoretical tools.

Even though the project concentrates strictly on the SOFC technology, the planned studies will have a much bigger impact, as in the process, the current state-of-the-art of HEOx studies, especially in terms of understanding their functional properties, will be greatly expanded. The expected formulation of design guidelines for effective HEOx air-electrode materials, and directions for their further advancement will provide an immediate impact on the extremely rapidly developing research fields of HEOx and SOFCs, and consequently, on the development of the next-generation, environmentally-friendly power grid.