The industrial revolution, which began in England at the end of the 18th century, would not have been possible if the invention of the steam engine had not been accompanied by the use of coal as a source of thermal energy indispensable for the generation of vapor. The application of the steam engine and the ensuing rapid growth of the coal mining industry revolutionized industrial production as well as both rail and maritime transport. The development of civilization over the last two centuries has been associated with constantly increasing use of energy per each human. Population growth, shrinking deposits of fossil fuels, and the climate change that has accompanied the ever-increasing greenhouse emissions are the main reasons why the 21st century must see a major breakthrough concerning the way in which the energy required for further progress is generated. The production of electrical energy based on thermonuclear microsynthesis is undoubtedly the future of the power industry, and is expected to meet the energy needs of humanity eventually. However, it is unlikely to be implemented by the end of this century due to various factors, including issues with the production of materials required to construct stellarators or tokamaks. The rate of global warming, which is largely a consequence of the development of the conventional power industry based on solid, liquid and gaseous fossil fuels, may be reduced by increasing the contribution of wind and solar energy in the energy mix. However, at certain latitudes the generation of electricity based on these two sources can be severely hampered by weather conditions, and this is also true for Poland. This inherent unpredictability makes it necessary to develop new technologies which might be used to store surplus energy, since this issue cannot be solved using the currently applied pumped-storage plants. One of the most promising solutions in this regard entails the production of hydrogen in solid oxide electrolyzer cells (SOECs). Since SOECs operate at high temperatures, they are capable of converting electrical energy not just into hydrogen, but also into more complex gas fuels, such as the so-called syngas. This gas is a mixture of hydrogen and carbon monoxide, and it can be used to synthesize liquid hydrocarbons, including methanol, ethanol or synthetic gasoline. The production of syngas by means of SOECs and via the co-electrolysis of water vapor and carbon(IV) oxide would also help mitigate climate change, because carbon dioxide – one of the main greenhouse gases – might be used to synthesize fuels and then collected and reused after their combustion.

In order for a solid oxide electrolyzer cell to operate with high efficiency, its operating temperature needs to be above 600°C. Such conditions, however, are associated with certain issues, including the high-temperature corrosion of metallic interconnects – a fundamental component of an electrolyzer. The interconnects serves several roles – it allows single cells to be connected and form stacks, ensures that the entire construction is sufficiently rigid, enables the flow of electric current through the stack, and transports reaction gases to the anode and cathode via channels located on both of its sides. Interconnects are currently made from high-chromium ferritic steels, since the latter are compatible with the ceramic components of an electrolyzer, i.e. the anode, cathode, and electrolyte, in terms of their thermal expansion coefficients. During oxidation, a scale with two layers – an inner layer composed of Cr_2O_3 and an outer layer consisting of the $MnCr_2O_4$ spinel – forms on this type of steel. The inner layer inhibits the formation of volatile compounds of chromium(VI). Such compounds cause the so-called "electrode poisoning" – a phenomenon that reduces the power efficiency of the device – and their presence is thus very undesirable. The formation of volatile chromium compounds can be prevented by applying protective-conducting coatings directly onto the surface of an interconnect. The materials initially used for this purpose included perovskite-type oxides such as $LaCrO_3$, $(La,Sr)CrO_3$, $(La,Ca)CrO_3$, which were subsequently replaced by far superior spinel-type materials – $Mn_{2-x}Co_{1+x}O_4$ (where x is typically 0.5 or 1) and $Mn_{1-y}Co_{2-y}Me_y$ (where y is 0.1 or 0.3, while Me = Cu, Ni, or Fe). Unfortunately, the cobalt applied in the latter type of materials is not only relatively rare, but it is considered carcinogenic both in its metal form and when in certain compounds. This necessitates the use of special preventive measures that increase manufacturing costs. The main objective of the proposed research project is to develop a new type of material for interconnect coatings. This composite material is to have a matrix consisting of the $Cu_{1.3}Mn_{1.7}O_4$ (CM) spinel, and to contain the $La_{0.95}Ni_{0.6}Fe_{0.4}O_3$ (LNF) perovskite with the composition (100-x)CMxLNF (where x=0, 5, 10, 20 and 30 wt%) in the form of inclusions in the matrix. It is worth emphasizing that this concept replaces cobalt with copper, which is much more readily available, less expensive, and more environmentally friendly. In order for the production of hydrogen to gain widespread popularity, electrolyzers must remain failure-free over a sufficiently long period of time – of the order of several dozen thousand hours. At the same time, their manufacturing cost needs to be kept at a minimum. This can be done by reducing the cost of each of their components, and the proposed research project is a step towards achieving that goal.