Progress is impossible without continuous technological development, but in certain cases new concepts cannot be implemented due to the lack of construction materials with the appropriate physicochemical properties. A common feature of all metallic materials that operate at high temperatures is their tendency to undergo corrosive degradation as a result of chemical interaction with the components of the surrounding environment. The medium in which such materials operate are mixtures of hot, corrosive gases. Examples include fumes from boilers used to generate energy, which – aside from oxygen and nitro gen – also contain significant amounts of carbon dioxide, water vapor, nitrogen oxides, sulfur oxides, and other aggressive gaseous agents. High-temperature corrosion cannot be prevented, but it can be controlled to some degree. The scale grows at a slower rate when the concentration of point defects in the oxide of which it is composed is low. Of all oxides, only Cr_2O_3, Al_2O_3 and SiO_2 are characterized by very low concentrations of point defects. The adhesion of Cr_2O_3 and Al_2O_3 scales improves significantly if a small amount of a so-called active element (Y, La, Ce, Sm,…) is added to the alloy. This effect was accidentally discovered nearly one hundred years ago. Unfortunately, in the first 50 years or so from the discovery of the reactive element effect (REE), hypotheses attempting to explain the underlying mechanism were not valid. Such disproven hypotheses include the formation of a so-called inter-layer with an intermediate thermal expansion coefficient, the mechanical “anchoring” of the scale by the precipitates of oxides of active elements, or the transport of mass via edge dislocations in chromium oxide. Perspectives on the cause of the REE changed as late as in the early 1980s owing to studies carried out at Boston’s MIT by means of a scanning transmission electron microscope (STEM) capable of magnifying an image up to 1,200,000 times. It was observed at this time that intergrain boundaries in the Cr_2O_3 scale formed on the Co-40Cr alloy with yttrium ions implanted underneath the surface contained more yttrium than grain interiors. The REE is still the subject of research, since many of the aspect related to these elements’ mechanism of action have not been fully explained so far. The discovery of the segregation of yttrium at grain boundaries in the Cr_2O_3 scale laid the foundations for the hypothesis postulating the formation of the yttrium-chromium perovskite ($YCrO_3$) within them and its gluing effect. It has not been demonstrated yet whether this perovskite truly forms at grain boundaries in these scales. To clarify this issue, the structure of grain boundaries in Cr_2O_3 scales need to be examined using atomic-resolution transmission electron microscopy (HRTEM). At present it has also become possible to examine the structure of a solid with atomic resolution in Poland. One of the leading research centers that specializes in such studies is the International Centre of Electron Microscopy for Materials Science at the Faculty of Metal Engineering and Industrial Computer Science of AGH UST in Kraków. This facility has the FEI Titan Cubed G2 60-300 analytical transmission electron microscope equipped with the ChemiSTEM system at its disposal. This apparatus allows chemical composition to be analyzed at an atomic resolution (70 pm). Studies of the structure of grain boundaries in Cr_2O_3 scales formed on metallic materials with an active element addition will attempt to verify the perovskite formation hypothesis.

Even though many important scientific discoveries have been made by mere coincidence, technical and technological progress occurs mainly through knowledge obtained based on systematic fundamental research. It is therefore reasonable to ask about the possible contribution of the insight gained during the implementation of the proposed project. The answer is quite simple; the thorough investigation of the structure of grain boundaries and of the interphase between the oxide and metallic phases in protective scales is essential to the understanding and the subsequent practical application of the reactive element effect in the design of various types of metallic materials intended for operation at high temperatures. The energy, aircraft, and automotive industries will always drive the demand for oxidation-resistant and heat-resistant materials.