Among different industrial branches, the energy and transport sectors, including the aviation and automotive industries, are developing at a particularly rapid pace. Despite many efforts and preventive measures, the problem of high-temperature oxidation linking both industries still takes a heavy toll on the efficiency of the technologies used in the industry, generating huge, multibillion-dollar costs. However, a second aspect of high-temperature oxidation crucial for this project, cannot be overlooked, which is the correct assessment of a material's resistance to aggressive operating conditions by means of strictly developed procedures based on advanced research methods. To address this issue properly, comprehensive studies taking into account the influence of temperature, atmosphere, oxidation time, and material modifications on the structural changes occurring in the entire system, especially within the initial stages of oxidation, must be considered indispensable. Therefore, versatile approaches, often utilizing methodologies outside of the state-of-the-art, and which will provide a simple, fast, and inexpensive way to study several groups of high-temperature materials in terms of the structural evolution independently on the oxidation stage, are of especially high demand.

Thus, the scientific aim of this project is to comprehensively describe the scale growth mechanisms on the model examples of high-temperature materials, such as alloys forming protective scales based on Al_2O_3 and Cr_2O_3 (alumina and chromia formers, respectively), using Raman spectroscopy under *in-situ* and *ex-situ* conditions. The studies will take into account the structural evolution of scales' phase composition including type, stoichiometry, mutual position, and sequence of the formation of the different phases, as well as the analysis of the stress state in relation to atmosphere, temperature, and above all, oxidation time (with the emphasis on the initial stages of exposures). Also, the impact of the selected, protective coatings will be considered. Furthermore, the proposed methodology will also address the internal oxidation zones and phase transformations taking place in the metallic substrates.

The following research questions posed in this project relate to each of the individual materials – what is the phase composition of the scales (including the Al_2O_3 polymorphs when relevant), depending on the atmosphere, temperature, and time of exposure considering both initial and further oxidation stages of:

- Ferritic steels for interconnects in Solid Oxide Fuel Cells (SOFCs) and Electrolyser Cells (SOECs),
- FeAl alloys for supercritical boilers and internal combustion engine components,
- Ni-based superalloys with a protective coating based on a NiCrAlY interlayer and a Thermal Barrier Coating (TBC) topcoat as the extremely efficient coating system for jet engine turbine blade applications,
- New-generation Co-based superalloys (potential alumina formers) for the replacement of currently used Ni-based superalloys.

The research hypothesis is that Raman spectroscopy (measurements in 1D, 2D and 3D scale) can provide key information leading to an understanding of oxidation processes in high-temperature materials, as a promising alternative to currently used methods such as X-Ray (XRD) or Electron BackScatter (EBSD) Diffraction and Transmission Electron Microscopy (TEM) - based ones (referred later as 'TEM') in terms of: phase composition evaluation, *in-situ* studies of the early oxidation stages and *ex-situ* studies for the verification of a material's long-term efficiency.

The main idea of the project is to establish Raman spectroscopy as a leading method for high-temperature oxidation studies. Other methods will be further used, either to supplement the data, or to provide the necessary context for comparison with the state-of-the-art techniques, which could potentially be replaced by Raman spectroscopy:

- SEM/EPMA (or EDS depending on scale complexity) – complementing the microstructure of surface and cross-sections, and elemental composition from the same area,
- XRD/GIXRD (depending on the scale thickness) – since Raman measurement is much more local than XRD, results of the *in-situ* XRD will complement the phase identification providing 'bulk' information, as well in case of Raman inactive vibrations,
- TEM – final validation of the results.

All in all, Raman spectroscopy can be an extremely convenient tool for the design of new metallic materials (via the understanding of the scale formation and degradation mechanisms) applicable in multiple branches of economy and industry, such as the aforementioned aviation, energy, and automotive industries, which are the key research areas for engineering sciences and, above all, are the primary recipients of scientific novelties originating from the materials science. Taking into account a technical base, PI's experience in project management and a research group's experience in structural research, timely and efficient execution of the project is guaranteed, which will result in numerous publications in high-ranking journals, deepening cooperation with strong scientific centres and rapid development in the field of the high-temperature oxidation.