DESCRIPTION FOR THE GENERAL PUBLIC

Composites are materials composed of at least two different components. The ability to select a variety of materials as composite components and their form, size and arrangement enables that properties of composites can be higher than that achieved for single-phase materials. This also provides a great opportunity for thoughtful development of the required material properties. This gives possibility to produce dedicated materials for a specific application. A very interesting group of composites are ceramic matrix composites. High hardness, chemical resistance and stable mechanical properties at high temperatures makes them much devoted to research papers. The addition of the second ductile component limits typical defects in ceramics: brittleness, low thermal conductivity, and more.

In recent years, two groups of composites have emerged of interest: hybrid and gradient composites. The components of hybrid composites are substrates that during the consolidation process (e.g. sintering at high temperature) react with each other and influence the final phase composition of the material. In gradient composites, the share of the reinforcing component changes along the chosen direction. One of the methods to achieve such a structure is slip-centrifugal casting. If the mold filled with ceramic-metal powder suspension ($\rho_{metal} > \rho_{ceramika}$) undergoes centrifugation, the centrifugal force will cause that metal particles move faster than ceramic particles to the surface of the sample.

This study combines these two concepts forming the structure of composites. The project will develop a method to produce hybrid gradient composites from ternary systems based on the Al_2O_3-Cu system with the addition of nickel, molybdenum and chromium respectively (element with similar density, higher and lower than Cu density). **The aim of the project is to determine the possibility of forming microstructure of the Al_2O_3-Cu composite with the addition of a third component, by selection of the type and volume of both metallic components and the formation of the gradient structure affecting the degree of occurrence of phase transformation (reaction) within the components. Microstructure will be analyzed in terms of its impact on local mechanical properties and electrical and thermal properties of the sample.**

It is planned to produce samples with homogeneous phases distribution with respect to each other (slip casting method) and with a gradient structure (centrifugal casting method). It is assumed to produce a material with a structure with isolated particles and with interpenetrating phases (percolating structure). Interpenetrating structure will be achieved by locating the metallic components in the gradient zone and sintering at a temperature higher than the melting point of copper. In research on the Al_2O_3-Cu system, the problem is the flow of liquid copper from a porous ceramic mold. We will prevent this phenomenon by addition of second metallic component that will form with Cu a solid solution (Ni) or a mixture of solid and liquid solutions (Mo and Cr) at the sintering temperature. Therefore, in order to obtain the assumed structure in the material, it is necessary to examine the possibility of controlling the location and migration of the liquid component during the sintering process by its initial arrangement and the additives that react with each other.

Due to innovative concept of forming the structure of composites it will be possible to obtain areas in the composite with increased thermal conductivity and high electrical conductivity. Such composites should also have increased mechanical properties relative to the ceramic due to the various mechanisms of inhibition of crack propagation. Subsurface zone, wherein the boundaries areas are occupied by the metallic component (percolation structure) should produce compressive stresses acting on the ceramic core.

Numerous samples of Al_2O_3-Cu-Ni, Al_2O_3-Cu-Mo, Al_2O_3-Cu-Cr systems will be produced during the project. The phase structure of these materials and mechanical properties (hardness and fracture toughness), electrical and thermal properties will be examined. The authors will determine the relationship between the contribution of components, composition of slurries, technological process (casting and sintering parameters) and the resulting structure and properties. Thanks to the research, the foundations of an innovative method of forming composite structures will be identified, which will combine the best features of ceramics (hardness, resistance to high temperature) with metal properties (crack resistance, good thermal and electrical conductivity).