Low-density alloys with relatively high strength and hardness, i. e. materials with high specific strength, are one of the main areas of research in the field of material science in the 21st century. The high specific strength of a material can be achieved by increasing its strength and/or reducing its density. The presence of Mg, Al and Ti as light metals in alloys provides a low density of such materials. Aluminium alloys also have good corrosion/oxidation resistance.

Increasing polycrystalline alloys' strength and hardness can be achieved, among others, by the presence of nanocrystalline structure. Nanocrystalline alloys usually have properties better than those of microcrystalline materials with the same chemical and phase compositions. These properties include primarily strength and hardness. The properties of nanocrystalline materials are affected by the small grain size and by the large contribution and nature of intercrystalline areas.

From the viewpoint of high strength and hardness, amorphous alloys are another interesting group of materials. Due to a diametrically different structure in comparison with crystalline materials (no long range ordering), while having the same chemical composition, amorphous materials may differ in properties from crystalline ones, e. g. they may exhibit higher strength and hardness than microcrystalline ones.

One of the methods of nanocrystalline and amorphous alloys production is mechanical alloying (MA). An advantage of this process is that alloys are formed by solid-state reaction. Thus, the use of MA overcomes problems such as large differences in melting or boiling points of the alloying components and evaporation or segregation that could occur during melting and casting. Another advantage of MA results from its versatility, i.e. its wide range of application possibilities. MA can be used to produce alloys with the supersaturated solid solution structure, alloys in immiscible systems, quasicrystalline phases and metastable phases, difficult or impossible to obtain by other methods.

The products of MA are in a powder form, whereas most applications require a bulk form. Therefore a necessary processing step is consolidation of milled powders. Applying too high temperature of consolidation may lead to excessive grain growth or crystallisation of an amorphous phase. The consolidation temperature should be high, but not as high as to cause those undesirable effects. Consolidation of nanocrystalline or amorphous powders into bulk full-density material with a nanocrystalline or amorphous structure preserved is therefore a task both important and difficult to perform. To fulfil this, the application of a high pressure during consolidation and limitation of the high temperature exposure time could be taken into account. The author of this proposal has successfully used a hot-pressing method for bulk nanocrystalline or amorphous materials production, and has demonstrated that the application of a high pressure hinders the grain growth at elevated temperature.

Over the last few years, high entropy alloys (HEAs) have been given significant attention from researchers. HEAs are a new class of multicomponent alloys in which the design of the materials is based not on adding solutes to a single base element, but on choosing elements that will form solid solutions when mixed at near-equiatomic concentrations. HEAs were originally defined as alloys containing 5 or more principal elements with concentrations between 5 and 35 at.%, but the field now includes materials with as few as 3 principal elements, and where the maximum element concentration may exceed 35 at.%. Initially, HEAs were considered as single phase alloys. However, it was later concluded that HEAs could also be multiphase alloys with different degrees of ordering, including intermetallic compounds or amorphous phases. New term such as complex concentrated alloys (CCAs) encompasses these new concepts, i.e. reducing the number of principal elements, increasing the maximum concentration and allowing the multiphase composition.

In recent years, researchers have been making efforts to design and manufacture low-density CCAs. These alloys, as new materials, will extend the range of available light-weight structural materials. If low-density CCAs are prepared by MA followed by suitable consolidation, they will have nanocrystalline, amorphous or mixed nanocrystalline-amorphous structure. Consequently, they will have hardness and strength superior to their microcrystalline counterparts. Nanocrystalline and/or amorphous low-density CCAs seem to be good candidates for materials with high specific strength.

The proposed project includes production of nanocrystalline and/or amorphous Mg-Al-Ti, Mg-Al-Ti-Fe and Mg-Al-Ti-Fe-Cr CCAs as well as investigations of their structure and selected properties. Various compositions of alloys, starting from the equiatomic ones, will be investigated. The compositions will be modified with the aim of producing a single-phase nanocrystalline or amorphous alloy or a two-phase material containing nanocrystalline solid solution and an amorphous phase. The alloys will be obtained by MA followed by high-pressure consolidation at elevated temperature. Suitable selection of consolidation conditions (pressure, time, temperature) should ensure preserving the nanocrystalline and/or amorphous structure formed in the course of MA or creating a nanocrystalline structure through the crystallisation of an amorphous phase.

The aim of the project is therefore creation of innovative light-weight materials with relatively high hardness.