Shape memory alloys find their application in many fields, from robotics, aircraft, automotive industry to biomedicine. The shape memory effect is observed in many materials and relies on a physical phenomenon occurring as a result of diffusionless, reversible and thermoelastic martensitic transformation. An equally important and closely related effect with martensitic transformation is the so-called super-elastic deformation. It involves forcing martensitic transformation by applying an external load without temperature. The most commonly used alloy in this group is NiTi alloy. However, it is quite expensive and difficult to shape by forming. On the other hand, Fe-based alloys show up to twice the super-elastic deformation, are cheaper to manufacture, and very easy to mold. The only drawback is achieving a fully reversible martensitic transformation in this type of alloys. An effective consideration is the introduction of coherent and very small precipitates by supersaturation and aging, which stimulate martensitic transformation. The process has been quite well controlled in monocrystalline Fe-based alloys. Polycrystalline materials, on the other hand, due to a much greater degree of microstructural complexity leave much more possibilities and at the same time ambiguity in the context of the proposed thermo-plastic treatment and chemical composition.

Therefore, the main goal of the proposed research program is to produce a polycrystalline material with appropriate texture components (deformation or recrystallization) and an appropriate grain size, which leads to a large superelastic effect in a polycrystalline material based on Fe. Both aspects will be obtained by using severe plastic deformation methods followed by one-step or two-step heat treatment. Another goal is to modify the chemical composition that will allow the initial martensite temperature (Ms) to shift towards higher temperatures. This, in turn, will significantly increase the potential for performing the work of the proposed material. This is planned in the project through a small addition of Nb or Ti. The final step will be appropriate heat treatment to obtain fine and coherent gamma precipitates based on experience gained during research using monocrystalline materials.

The alloys will be prepared from pure elements: iron, nickel, cobalt, aluminum, tantalum, niobium, boron, titanium. Plastic deformation will be imposed using high pressure torsion or hydrostatic extrusion to obtain the a strong texture. Texture and microstructural analyses will be carried out using 3D FEI Quanta scanning electron microscope equipped with the TSL EBSD system. The microstructure and chemical composition will be analyzed by means of high resolution analytical transmission electron microscopy. The phase analysis will be carried out using high-energy synchrotron X-rays.

As a result of the above, a polycrystalline material exhibiting a very high superelastic strain will be obtained. In addition, a thorough analysis of the effect of crystal texture, particle size and grain size on the superelastic effect will be performed.