The present project is aimed at the development of a novel computer model of the so-called FAST technology. The FAST is an acronym for the field assisted (or activated) sintering technology. Sintering is a material manufacturing technology, in which a loose or loosely bonded powder is consolidated (sintered) under applied pressure at an elevated temperature (below the melting point). In the FAST sintering temperature is obtained using the electric current. the electrically conductive powder is fed into a graphite die, pressed between two graphite punches and heated by Joule heating due to the electric current flowing through the tools and the sintered powder. An important advantage of the FAST over conventional powder metallurgy processes is its efficiency, a fast heating and cooling rates thanks to the Joule effect and a faster densification and consolidation of the powder since the Joule effect at the contact area increases locally temperature and intensifies diffusion, main sintering mechanism.

FAST technique is considered as a key technology for a new generation of materials. The main advantage of the FAST resulting from the short process time is related to the possibility to sinter materials without significant grain growth, which has a fundamental importance for manufacturing of nanomaterials. While the FAST technology has big advantages, its complexity brings about significant difficulties. Computer modelling can provide a valuable tool for better understanding and design of the FAST process.

Modelling of the FAST process is one of the most challenging problems in material modeling. The performance of the FAST process is a result of a complex interaction of electrical, thermal and mechanical phenomena. Therefore the FAST process should be modelled as a coupled thermo-electromechanical problem. In the literature, there are quite few fully coupled thermo-electro-mechanical models of the FAST process and only few attempts have been undertaken to develop micromechanical models capable to simulate directly microstructure evolution during FAST processes. The research proposed in the present project is aimed to fill this gap.

The project is aimed to develop a numerical model which will take into account the multiphysics nature of the FAST process and phenomena occurring at different scales, at the micro- and macroscale. The microscopic model will be developed in the framework of the so-called discrete element method (DEM). The DEM is a relatively new modelling method in which the material is represesnted by a large assmebly of particles (discrete elements) interacting with one another by contact forces. It is a suitable tool to model particulate materials. The present work is an extension of the research on discrete element and multiscale modelling of powder sintering carried out by a team led by the principal investigator.

Research work in the present project will comprise development of the macroscopic finite element model of the FAST process. The microscopic and macroscopic models will be coupled with each other. The macroscopic simulations will be used to provide the boundary conditions to the microscopic analysis. The results of simulations at the microscopic level will be used to determine effective macroscopic properties which will be used in the simulations at the macroscopic level. Both the microscopic and macroscopic numerical models will consider three physical fields: thermal, electric and mechanical ones coupled with each other.

Theoretical and numerical investigations will be combined with the experimental studies of the FAST process with copper and intermetallic NiAl powders. Laboratory measurements will allow us to obtain material properties necessary for numerical simulations. The experimental studies of the FAST processes will provide information about the process parameters and evolution of the powder material during the process. The experimental data will be necessary for development and validation of the numerical models.

The proposed research will have several original contributions with respect to the state of the art in numerical modelling of the FAST process.