Most of numerical simulations of elasto-plastic material deformation conditions are carried out by means of the finite element (FE) method, which can be successfully used in modeling of standard plastometric tests (e.g. compression, tension, torsion) as well as complicated metalforming operations (e.g. closed die forging, porthole extrusion, shape rolling). However, the accuracy of a finite element solution, among finite element mesh density or initial and boundary condition definitions, is particularly related to proper description of material hardening behavior.

Plastometric tests at different deformation conditions are often used to provide information on material response during loading. To improve mathematical description of obtained results, interpretation of these data can be efficiently carried by means of the inverse analysis technique. That way influence of heterogeneities related e.g. to friction or deformation heating, can be taken into account and eliminated from the solution. Eventually, set of homogenized flow stress data in the investigated range of process conditions is provided. These data are then usually described by a single flow stress equation representing behavior of the entire material, implicitly including influence of local morphological heterogeneities such as different phases, inclusions, precipitations etc., during FE analysis. Advantages provided by the approach are widely appreciated and used in scientific and practical industrial investigations of metalforming processes.

However, it seems that since the beginning of new millennium the approach not always provide satisfactory description of material behavior. This is mainly related to the fast development of modern metallic materials like complex multi-phase steels, which are characterized by elevated material properties that are directly linked to sophisticated microstructures. Interactions between different phases, inclusions or precipitations influence microstructure response to processing and exploitation conditions and should not be described by a single homogenized flow stress model. **Thus, presented conventional numerical approaches referred in the literature as mean field models, do not meet requirements of modern material science, which is trying to develop new materials based on close relations between sophisticated microstructure morphologies and elevated in-use properties.**

That is the reason why, it is so important to develop numerical models that can take into account the underlying microstructure morphology and its evolution in an explicit manner. This class of models is called full field approaches.

To address presented issues, different solutions capable of detailed, local investigation of material behavior have recently been developed such as: image based modeling, explicit microstructure modelling etc. Their common feature is representation of morphology of investigated microstructures in such a way that each important morphological feature is presented explicitly.

Recent research carried out by the principal investigator (PI) on development of this class of models, in particular based on the cellular automata (CA) method, have proven their advantages and immense capabilities in solving practical industrial issues (e.g. microstructure microstructure evolution, fracture initiation and propagation etc.) at the completely new level of computational accuracy.

Unfortunately, due to the discrete nature of the cellular automata, this method has some major disadvantages when a crucial high temperature phenomenon controlling microstructure evolution under deformation simulations called the dynamic recrystallization is considered. Particularly proper description of a computational domain deformation under plastic forming conditions is a limitation.

From the CA method assumptions the computational domain is discretized by a regular grid of cell with the same dimensions and neighborhood. In this case, a modelling of a geometrical deformation of computational domain is the primary disadvantage of this approach as it cannot be easily introduced. In case of the static recrystallization that occurs after metalforming operations, this is not an issue as the CA space is no longer subjected to deformation. **However, for the dynamic recrystallization occurring during deformation, neglecting of geometrical changes of microstructure significantly affects quality of the model predictions.** In many recent papers different simplified space deformation mechanisms or even its total omission have been used, what is unacceptable when the dynamic recrystallization phenomenon is investigated.

Therefore, the present research is directed towards solving this limitation. Primary interest is put on development of a complete new class of DRX models based on the CA method. The solution is founded on a direct full coupling of a variation of the CA method called the random cellular automata method with the finite element method. The random CA method is responsible for modelling of microstructure evolution progress in an explicit manner while direct coupling with the FE naturally solves the problem of computational domain deformation issue. The concept of the concurrent RCAFE (random cellular automata finite element), in contrast to the classical CAFE method, lies in the assumption that the cellular automata cells directly correspond with finite element integration points.

It is expected that obtained new knowledge will be the basis for the road map describing advantages and limitations of this new very promising class of microstructure evolution models based on a full field material representation concept. At present there is no information on this matter in the scientific literature.