The creation of new types of polymeric materials is in constant demand and is usually carried out at the stage of polymer synthesis or as a result of their chemical or physical modification. The latter is the most promising from the point of view of industrial mass production. In the physical (structural) modification of polymers, a specific change in the supramolecular structure occurs under the influence of physical factors, although the chemical structure of the macromolecules does not change.

The purpose of creating specific structures is to improve application-specific properties. For example, highly oriented structures are desired to achieve extremely high modulus and fracture toughness as well as improved solvent resistance in amorphous and semicrystalline polymers; phase transitions are desired to improve ductility (the transition from α-phase to γ-phase in polypropylene and polyamide-6) or to manifest the piezoelectric effect (the transition from α-phase to β-phase in polyvinylidene fluoride); crystal structures with a high degree of continuity are used to achieve an extremely low coefficient of thermal expansion of the order of $(1\text{-}10) \times 10^{-6}$ K^{-1} as in invar alloys, etc.

Structural changes in the material can also be achieved by deformation. Deformation-induced structural and phase changes in polymers occur in the plastic deformation region. However, many desirable structural states, such as structures with high perfection or large-scale molecular alignments, are not achieved in most polymers because they fail mechanically prematurely.

The project proposes to pay attention to the region of ultrahigh plastic (megaplastic) deformations (MPD). It is proposed to reach this range by intensifying the energy of elastic deformation. The project hypothesizes that significant elastic energy introduced into the polymer during deformation will enable the activation/opening of additional channels for energy dissipation, thereby delaying the failure stage and enabling deeper structural and phase transformation. These channels are believed to be dynamic recrystallization, phase transitions, dislocation rearrangement, and the release of latent heat from deformation. The onset of these processes will make it possible to determine physically justified value of the plastic strain corresponding to the transition to the MPD range (i.e. the boundary between the macroplastic and megaplastic deformations). Finally, we will try to give a rigorous definition of MPD. In the project, a unified physical mechanism of the processes occurring in polymeric materials at ultrahigh plastic strains will be investigated. It will be studied on the example of a series of polymeric materials (amorphous, semicrystalline, polymer blends) with different morphology (linear chain structure or with branching, with possible occurrence of crystal polymorphism under the influence of plastic deformation or thermal treatment). The studies will be carried out in a wide range of temperatures and pressures and at different strain rates. Our pilot experiments have shown that a number of interesting phenomena can occur in the megaplastic deformation region that have not been observed in the plastic deformation region, such as strain-induced diffusion processes, the mixing of immiscible polymers, the polymerization of compounds that do not otherwise yield high molecular weight products in the solid state (maleic anhydride) and substances that are difficult to polymerize (acetylene derivatives), whose polymerization only occurs under harsh conditions at high temperatures. Their implementation will enable the formation of principally new structural states that can be used to develop new approaches to polymer processing technologies such as mechanical recycling of mixed plastic waste, solid-state consolidation of powder polymers, and solid-state polymerization. The outcome of the project will be that the theory of strength and plasticity of polymeric materials will be significantly advanced by the discovery of the properties of polymers in a new range of plastic deformation - ultrahigh (megaplastic) deformations. Such deformations appear to offer greater opportunities for significant structural and phase transformations in polymers and provide a new approach to creating materials with improved physical and mechanical properties.