Polymers are macromolecular compounds comprised of many repeated elementary subunits called monomers. Polymers are important class of materials belonging to soft condensed matter. Polymers are widespread. Synthetic macromolecules are inevitable ingredients of commonly used materials, including plastics, rubbers, fibers, textiles, resins, glues and many others. Large group of materials which are biological in origin also contains polymers. These are for instance proteins, nucleic acids (DNA) or polysacharides (starch). Of particular importance for polymer sciences is theoretical description of macromolecule conformation, i.e. spatial polymer configuration. Many physical properties are manifestations of the underlaying polymer conformation. One of the most important factor influencing polymer conformation is macromolecular architecture. Typical polymers are in a form of linear chains. The progress in polymer synthesis, which was carried out in last decades, enables to manufacture polymers which are structurally much more complex. The examples are cyclic polymers which have no free ends and branched polymers. The latter are represented by bottlebrush polymers which are composed of densely spaced side chains grafted along a central linear backbone. The change in architecture from linear to more complex substantially modifies structure, dynamics, rheology as well as mechanical properties of polymeric materials. This provides large scope for theoreticians who by fine tuning of microscopic structure of macromolecules can design advanced materials with macroscopic properties that are unattainable for conventional linear polymers.

This project aims to investigate relationship between macromolecular architecture and physical properties of polymers. The main goal is to develop theoretical models that would provide foundation for molecular design of polymeric materials with unique structural and mechanical features. For this purpose we will explore bottlebrush and cyclic polymers. In particular, in the course of the study we will determine how lack of free ends and presence of graft in polymer conformation affects:

- microphase separation of copolymers and resulting morphology of formed nanostructures
- miscibility and toughness of polymer blends
- softness, elasticity and thermoplasticity of block copolymers
- thermosensitivity

The proposed research will make a significant contribution to the advancement of polymer physics and is related with specific applications in nanotechnology, medicine and mechanical engineering of (bio)materials.