The objective of the project is the development of a novel method of the synthesis of silver and gold nanostructures in a continuous-flow reaction-discharge system based on low power atmospheric pressure glow microdischarge generated in contact with a flowing solution, i.e., a flowing liquid cathode. The project envisages the evaluation of the effect of different operating parameters of this system, in which the microdischarge would be sustained in a gap between a flowing liquid cathode and a gaseous microjet, fed with various discharge gases (i.e., argon, helium, nitrogen, oxygen, air) or a solid metallic electrode in the open-to-air atmosphere, on optical and granulometric properties of resulting nanoparticles. In addition, mechanisms of plasma-chemical reactions and processes at the liquid-microdischarge interface, responsible for the production of nanostructures of silver and gold, would be elucidated. The project assumes that the liquid-microdischarge interface in the studied continuous-flow reaction-discharge system is a rich source of reactive oxygen and nitrogen species and solvated electrons that directly take part in reduction reactions of precursors of nanostructures of silver and gold, affecting the development of stable and homogenous nanostructures of these metals of given size and shape. It is also supposed that the operation of the microdischarge in the atmosphere of nitrogen, oxygen or air would result in an increase in the concentration of reactive oxygen and nitrogen species and solvated electrons at the liquid-microdischarge interface and be responsible for improving the efficiency of the production of nanostructures of both metals. The replacement of the gaseous microjet with a solid metallic electrode and the operation of the microdischarge fully in the atmosphere of the surrounding air would simplify the design of the reaction-discharge system and reduce costs of the production of nanoparticles by this plasma-based method.

Among different methods used for the production of silver and gold nanostructures the most popular are chemical, potochemical and sonochemical reduction methods. In chemical reduction methods there is a need to apply appropriate reducing agents in addition to compounds that prevent the aggregation and the sedimentation of resulting nanoparticles. Both groups of these reagents can be however toxic that limits the application of produced nanoparticles in biological systems. Therefore, new methods of the synthesis of nanostructures of silver and gold, not being accompanied by the formation of toxic products, faster than existing ones or allowing the production of nanostructures of predetermined size and shape, are extensively developed and examined.

Such new and alternative to the chemical reduction means of the production of nanoparticles of silver and gold are biological and relatively newly developed plasma-based methods. In processes of the biosynthesis of nanostructures of silver and gold, natural occurring substances are typically applied, i.e., plant, bacterial, fungi and algae extracts. These natural substances posses both reducing and stabilizing properties and concurrently do not exhibit toxic effects on living organisms. Nevertheless, their usage is associated with an indispensable need for the isolation and/or the purification of resulting nanostructures. This makes the biosynthesis process quite long and expensive.

A remedy to a protracted and long biosynthesis of nanostructures of silver and gold are plasma-based methods. Because of a suitable reaction environment in the liquid-plasma interface, including charged species and free radicals, there is no need to use any additional reducing agents. This enables to carry out a one-stage synthesis of nanostructures of silver and gold with reduced costs and efforts. Unfortunately, in plasma-based methods developed so far and reported in the literature for the synthesis of metallic nanostructures in solutions, stationary (non-flowing) systems with atmospheric pressure plasmas generated in contact with liquids were only used. The operation of these systems is, however, usually accompanied by an uncontrolled interaction of plasmas with solutions of precursors of nanoparticles of silver and gold. By a contact of gaseous plasma jets with liquids, solutions of precursors of nanoparticles evaporate, leading to a change in the distance between the surface of these solutions and plasma sources. In a consequence, excitation conditions in plasmas and plasma-chemical processes are disturbed that is manifested by changes in the concentration of reactive oxygen and nitrogen species as well as solvated electrons at the liquid-plasma interface. Under such conditions, the synthesis of the metallic nanostructures can be irreproducible. In addition, it is more difficult to control optical and granulometric properties of obtained nanoparticles. The size and the shape of nanoparticles may be varied within a fairly wide range and, in extreme cases, these properties of nanostructures can be extremely undesirable.

It seems that a solution of problems related to the synthesis of nanoparticles of silver and gold by using atmospheric pressure plasmas in stationary systems would be continuous-flow systems and their application for the synthesis. This would be an important step in the development of plasma-based and plasma-supported methods of the synthesis of metallic nanostructures. It appears that the use of atmospheric pressure glow microdischarge, generated between the flowing liquid cathode and a gaseous microjet fed with nitrogen, oxygen or air, or a solid metallic electrode in the atmosphere of the ambient air, would increase the efficiency of the production of nanoparticles of silver and gold and their bimetallic nanostructures. At the same time, proposed reaction-discharge systems could provide a greater control over the course of the synthesis process and the quality of obtained nanostructures because of a constant distance between the renewed surface of the flowing liquid cathode and a gaseous microjet or a fixed electrode and a repeatable penetration of the surface layer of precursors' solutions by the microdischarge. The production of nanoparticles of silver and gold or their bimetallic nanostructures with the continuous-flow reaction-discharge system, based on the use of atmospheric pressure glow microdischarge generated in contact with the flowing liquid cathode in the atmosphere of nitrogen, oxygen or air (instead of argon or helium), would significantly reduce costs of such a process. This method would be competitive to methods of the synthesis of silver and gold nanostructures by the chemical reduction. Moreover, under optimal conditions of the process, it would be possible, in a relatively short time, to produce large amounts of biocompatible nanoparticles of silver and gold with specific optical and granulometric properties. The use of a solid metallic electrode in place of a gaseous microjet and the operation of the microdischarge fully in the atmosphere of the ambient air would additionally reduce costs of this continuous-flow reaction-discharge system and the process of the production of metallic nanoparticles.

The evaluation of the effect of working parameters of the microdischarge on optical properties, the size and the shape of obtained silver and gold nanostructures in addition to the investigation of mechanisms of plasma-chemical reactions occurring at the liquid-microdischarge interface, responsible for the production of nanostructures of both metals, could offer an opportunity for the synthesis of nanostructures with predetermined size and shape. The selection of optimum operating parameters of the microdischarge would allow to control the performance and the progress of this process. It seems that the developed and characterized continuous-flow reaction-discharge system could be used in the future not only for the synthesis of nanostructures of silver and gold, but also of other metals, for example, copper, iron, manganese. Moreover, due to the presence of reactive oxygen and nitrogen species as well as solvated electrons at the liquid-microdischarge interface, the microdischarge could be successfully used for the efficient sterilization of various kinds of microorganisms on non-porous surfaces and for the treatment of sewages and wastewaters from toxic organic compounds organic. For this reason, the project is of a vital importance for the development of nanochemistry and nanotechnology, as well as biotechnology, microbiology and environmental engineering.