Objective of the project:

Nowadays, from industry point of view, there is a growing interest in plasma sources for plastic and metal surface modifications e.g. surfaces of cars parts. Simultaneously, the importance of small devices, with low energy consumption, are increasing. Thus the so called "downsizing" is also present in plasma science. The development of plasma sources of the required parameters is a recent trend in plasma science and engineering. Currently, worldwide there is high interest in the plasma technology.

A novel microwave plasma source of the unique plasma sheet shape was designed and built in the Centre for Plasma and Laser Engineering of the Szewalski Institute of Fluid-Flow Machinery Polish Academy of Sciences. It operates at atmospheric pressure and under standard microwave frequency of 2.45 GHz. Such a unique shape of the generated plasma sheet, protruding outside the quartz box in which the plasma is generated, is suitable for surface treatment, being attractive for industry. To fully evaluate the potential application of the new plasma source the basic knowledge about the properties of the generated plasma is required. The role of the different parameters on the plasma properties is necessary to know. These parameters include, eg. a kind of working gas and its flow rate, microwave power delivered to the plasma source and the geometry of the plasma source.

The main objective of this project is characterization of properties of plasma sheets generated at atmospheric pressure using microwaves of 2.45 GHz, and investigations of their generation methods.
Obtained results (e.g.: spectroscopic investigation of microwave plasma, numerical modelling, experimental investigations) will be used for elucidation of microwave plasma sheet applicability, mainly for material engineering (i.e. treatment of PCBs, PTFE, polyethylene, metals, glass).

Description of the research:

Aim of the project will be achieved by performing spectroscopic studies (OES – Optical Emission Spectroscopy and LIF – Laser Induced Fluorescence), numerical modelling of electromagnetic field distributions (using Comsol Multiphysics software equipped with RF module) and investigations (experiment and modelling) of electrodynamic characteristics.

The research in the project will give answers to fundamental questions:
- what is the composition and temperature of the plasma in various profiles,
- what is the electromagnetic field distribution in the plasma sheet region,
- is it possible, and if yes then how, to control the microwave plasma properties via changes in geometry of microwave plasma sheet source,
- whether by adding the appropriate additives to the working gas can be eliminated or reduced filamentation phenomenon, which is observed in microwave discharge in argon at atmospheric pressure,
- how to improve efficiency of energy transfer from electromagnetic field into the plasma,
- what changes on materials surfaces are caused by the microwave plasma in relation to its properties.

Present reasons for choosing the research topic:

This project has cognitive significance. The knowledge plasma sheet properties and methods of its generation using microwaves at a frequency of 2.45 GHz will be acquired. Nowadays, there is a trend of wide meaning miniaturization in many areas of life. The importance of small devices, with low energy consumption, are increasing. The development of plasma sources is also a recent trend in plasma engineering. Plasma is an object of interest of research centers and commercial companies.

The practical implementation of the microwave plasma sheet sources will be possible subject to obtaining good knowledge about the principles of their construction, the properties generated plasma and its effectiveness.

Nowadays, from industry point of view, there is a growing interest in not expensive plasma sources for plastic and metal surface modifications e.g. surfaces of cars parts. The plasma treated material changes its surfaces properties. The plasma in the form of a plasma sheet with moderate temperature is preferable. Recently existing devices dedicated to plasma surface treatment, mainly radio frequency based, are of high cost. It further increases investment and operating costs. Meanwhile, there are entrepreneurs interested in reducing the cost of surface treatment process. In this case one of the way is to use a microwave (2.45 GHz) frequency plasma at atmospheric pressure. Operating at atmospheric pressure eliminates an expensive vacuum apparatus. Using standard microwave frequency of 2.45 GHz allows to use cheap commercial magnetron such as that installed in microwave oven. Therefore, to meet industry expectations of low cost source of non-thermal plasma (of required temperature) for surface treatment we designed and built atmospheric pressure plasma sheet source operated at 2.45 GHz.

The knowledge about the new kind of plasma should be of interest to other researchers in the world, and implementations in industry and science will also include new place of employment.