DESCRIPTION FOR THE GENERAL PUBLIC

Plasma, called the fourth state of matter, is a strongly ionized, quasi-neutral medium exhibiting a collective behavior. Such behavior is connected with the long-distance electromagnetic interactions between charged particles present in plasmas. While plasmas are common in the Universe, they can be hardly encountered on Earth. They are created during atmospheric discharges and are visible as aurora formed in upper atmosphere. Plasmas can be, of course, produced in laboratory conditions for different purposes like nuclear fusion, charged particle beams or X-ray generation, and research concerning so called laboratory astrophysics or laboratory astrochemistry. Plasma is also utilized for various industrial processes connected with microelectronics, micromechanics, nanotechnology, thin layers deposition or surface processing. The corresponding plasmas are created employing different plasma generators, mainly based on electrical discharges. These are low temperature plasmas with the electron temperature of the order of several to tens kelvins. Plasmas can be produced in gases under low pressure, in special chambers, or under atmospheric pressure. In many cases, especially under atmospheric pressure, a strongly non-equilibrium plasma is created, where the ionization degree is very low. A density of electrons released due to ionization of a gas being a medium for the plasma creation, is only a small fraction of the atomic/molecular density. In extreme cases it can be thousands times lower.

The low temperature plasma can be, however, created by a quite different method, as a result of photoionization of gases with intense electromagnetic radiation pulses. Energy of incident photons in this case should exceed at least ionization potentials of atoms or molecules, however, in some cases can exceed even binding energies of core electrons. In case of sufficiently high photon flux, low temperature plasma with large contribution of ionic species can be produced. It is clear that effectiveness of plasma interaction with surface to be etched or modified would be much better in this case comparing to plasmas dominated by neutral particles. Author of the project proposes to perform research concerning creation of low temperature photoionized plasmas and demonstration their usefulness for surface processing and spectrochemical analysis. As a source of the ionizing radiation from an extreme ultraviolet or soft X-ray range a laser plasma will be utilized. This kind of plasma with an electron temperature of the order of hundreds of thousands kelvins can be produced in vacuum systems, where the ionizing radiation can propagate and be effectively focused on large distances. It can be also produced under atmospheric pressure, where the propagation is possible only in light gases like helium or hydrogen on short distances of the order of several mm.
In the first case the gaseous medium to be ionized will be injected into the focal region, in the second case will be formed in the vicinity of laser plasma. In both cases a number of absorbed photons should be comparable to the number of atoms present in the irradiated volume. It would give a possibility to obtain a high electron density, even a few orders of magnitude exceeding the density reached in standard plasma generators.

Plasma diagnostics will be based mainly on spectral measurements in the wide spectral range from extreme ultraviolet to the long-wavelength edge of the visible radiation. The electron temperature will be estimated based on relative spectral intensities of emission lines and based on numerical modelling of plasma emission. The electron density will be determined taking into account Stark broadening of selected spectral lines, for example from the Balmer series of a hydrogen admixture.

The plasma generators developed in frame of the project will be used for demonstration experiments concerning surface processing of selected materials. Due to exposure on the low temperature plasma either morphology or chemical changes in the near surface layer are expected. The surface morphology will be investigated using microscopic methods, while changes of the molecular structure or chemical composition employing spectroscopic methods. Changes are expected only in the near surface layer, hence, the best method seems to be the X-ray photoelectron spectroscopy.

Demonstration experiments concerning spectrochemical analysis of the liquid matter are planned mainly employing the plasma generator working under atmospheric pressure. The corresponding spectral measurements are planned in the visible and ultraviolet range.