EUV induced plasmas created in atomic and molecular gases

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Photoionized plasmas induced by irradiation of gases with X-ray or extreme ultraviolet (EUV) radiation are present in Space, where such ionizing radiation is produced by various astrophysical objects and can propagate over long distances. Photoionized plasmas can be also produced in laboratory conditions using intense EUV or X-ray radiation sources. Basic studies of these plasmas concern laboratory astrophysics, astrochemistry, inner-shell processes, X-ray lasers or matter in extreme states. Such plasmas can be also considered for some technological processes like reactive etching or surface treatment. In the latter case simultaneous plasma and radiation treatment of materials is possible.

In this work investigations of EUV induced low temperature plasmas with relatively high electron density were performed. Various laser-produced plasma (LPP) EUV or soft X-ray (SXR) sources were employed for creation of such plasmas. The sources were based on two different laser systems with pulse energies ranging from 0.8 J to 10J and pulse duration 4 ÷ 10 ns. The experimental arrangements were equipped with the EUV/SXR collectors for focusing of the radiation onto the gas to be ionized or the gas was injected in the vicinity of the LPP. Ellipsoidal or paraboloidal collectors were also used in detection systems employed for measurements of weak EUV emission from the low temperature PP.

Different gases, used for creation of the EUV induced plasmas, were injected into the interaction region, employing an auxilary gas puff valve. Irradiation of the gases resulted in ionization and excitation of atoms and molecules forming low temperature plasmas. Spectral investigations were performed in EUV range using a grazing incidence, flat-field spectrograph (McPherson Model 251), equipped with a 450 lines/mm toroidal grating. The UV/VIS spectra were measured using an Echelle Spectra Analyzer ESA 4000. The spectra contained spectral lines corresponding to radiative transitions in atoms, molecules, atomic or molecular ions. For analysis of the EUV spectra numerical simulations were performed, using a collisional-radiative PrismSPECT code. For computer simulations of the molecular spectra measured in the UV/VIS range a LIFBASE and Specair codes were employed. Apart from that, the electron temperatures of plasmas created in different gases were estimated employing a Boltzmann plot method. The electron density was estimated based on Stark broadening of selected spectral lines.