Recombining Plasma Expanding in Low-Pressure Region

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High density thermal plasma expanding in low-pressure region is of immense scientific interest and has numerous applications. The monomer seeded plasma is utilised for plasma processing of surfaces, i.e. deposition, surface etching, nitriding and for many more applications depending on the seeding materials. Conditions prevailing in the Tokomak edge plasma can also be simulated using the low temperature, high flux obtained with cascaded arc thermal plasma source. Various species of the high density flowing plasma generated in a narrow channel (few mm diameter) of an arc discharge are usually in thermal equilibrium. In this presentation experimental measurements made in the thermal plasma with particular reference to the kinetics in molecular plasma and surface nitriding will be discussed. The cascaded arc source is coupled to a low-pressure chamber wherein the plasma generated in the source expands while propagating in the axial direction. Typical parameters of argon plasma in the expansion region are: plasma density, 10^{19} m^{-3} , electron temperature, 3000 K for argon flow rate of 3 slpm and 60 A arc current. The current in the arc is distributed over three water-cooled tungsten cathodes, which not only prolongs the life of electrodes but also improves the uniformity of the system. If argon is replaced with molecular gas hydrogen / nitrogen, recombination processes set in the expanding plasma. The plasma density drops significantly and the electron temperature also reduces. In hydrogen plasma, charge transfer between the rovibrationally excited hydrogen molecules followed by dissociative recombination reactions provides the fast loss mechanism. Axial magnetic field helps to contain and prolong the hydrogen plasma beam in the chamber. Side injection of hydrogen in one of the cascaded arc plates stabilises the arc, improves the ion flux, and is also beneficial for improving the cathode life. A combination of nitrogen and hydrogen plasma generated in the system has led to an efficient process for nitriding of machinery components.