MODELING INTERACTION OF THERMAL PLASMAS WITH ELECTRODES*

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An adequate organization of current transfer from the plasma to electrodes is critical for performance and lifetime of any arc discharge device. As far as high-intensity discharge (HID) lamps are concerned, an inadequate organization of current transfer to electrodes can cause such highly undesirable effects as degradation of the electrodes, blackening of the walls of the lamp, enhanced heat conduction losses, electromagnetic interference emissions.

Electrodes of arc discharges have been under intensive investigation for many decades. However, experimental investigation has been hindered by the fact that phenomena governing plasma-electrode interaction take place in thin layers adjacent to electrode surfaces which are extremely difficult to resolve due to their very small dimensions, as well as by extreme conditions typical for arc discharges. Even such basic quantities as near-cathode and near-anode voltage drops have been reliably measured relatively recently. The lack of reliable experimental data was detrimental to theory, as was a late realization of the fact that different modes of current transfer, typical for electrodes of arc discharges in general and, in particular, for electrodes of HID lamps, represent self-organization phenomena and must be described as such. As a consequence, reliable experimental data and self-consistent theoretical models started to emerge only in the 1990s and mostly for cathodes.

The aim of this talk is to summarize present understanding of cathodes and anodes of high-pressure arc discharges. The focus will be on theoretical models and methods of simulation and special attention will be paid to identifying molecular and atomic data needed for calculations of plasma-electrode interaction for conditions typical of HID lamps. The most of concepts under review is applicable not only to low-current high-pressure arc electrodes but rather to electrodes of arc discharges in ambient gas in general, in particular, to cathodes of low-pressure DC discharges in fluorescent lamps (the so-called thermionic arcs), and some concepts apply also to arc discharges in vacuum. On the other hand, some physical mechanisms that are unimportant under conditions of low-current high-pressure arcs, although may come into play under other conditions, are left beyond the scope of this talk.

The topics to be covered by the talk include: analysis of basic physics of near-electrode plasmas in high-pressure low-current arc discharges with the aim to identify mechanisms governing current transfer to cathodes and anodes; a review of the most important results on the theory and modelling of plasma-cathode interaction; a comparison with the experiment; a discussion of results on the plasma-anode interaction and of main factors hindering or facilitating investigation of the near-anode physics; modelling electrodes of alternate current arcs and integration of models of plasma-electrode interaction into codes describing the whole system arc-electrodes; a summary of molecular and atomic data needed for calculations of plasma-electrode interaction for conditions typical of HID lamps.

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