Spots on electrodes of DC discharges: self-organization theory and its applications

M. S. Benilov
Departamento de Física, Universidade da Madeira, Largo do Município, 9000 Funchal, Portugal
benilov@uma.pt

The existence of multiple modes of current transfer to electrodes of gas discharges is rather the rule than the exception. In particular, it has been known since the early 1950s that current transfer to cathodes of high-pressure DC arc discharges can occur in the diffuse mode, where the current is distributed over the front surface of the cathode in a more or less uniform way, or in the spot mode, where most of the current is localized in a small area (cathode spot). Similarly, it has been known for many decades that current transfer to cathodes of DC glow discharges can occur in the abnormal mode or in the mode with a normal spot. Recently, also modes with steady-state patterns of several spots have been observed.

Different modes of current transfer to electrodes of DC gas discharges are of considerable scientific interest and of critical importance for design of a number of technical devices. Although this topic has been under intensive investigation for several decades, self-consistent theoretical models started to emerge only in the 1990s, after it has been realized that different steady-state modes of current transfer represent self-organization phenomena and as such are intimately related to existence of multiple steady-state solutions existing at the same discharge current, that must be admitted by an appropriate theoretical model.

In the case of cathodes of high-pressure arc discharges, a reasonably complete theory has been developed along these lines during the last decade. The theory has been convincingly validated by extensive experimental data and is widely used for industrial applications, such as high-intensity discharge lamps and high-power current breakers.

In the case of glow cathodes, the theory started to emerge only recently. Although physical mechanisms of current transfer to glow (cold) and arc (hot) cathodes are very different, the overall patterns of self-organization leading to appearance of multiple modes in both cases are remarkably similar. Identification and understanding of these similarities facilitate research in both fields.