Electrodes in HID lamps

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Electrodes provide the electrical connection between the power supply and the gas discharge of a lamp. They have to supply charge carriers at the cathodic side and to collect electrons at the anodic one. Electrodes are operated in a stationary mode or in different AC modes (mains frequency at 50 or 60 Hz, switched DC of RF at >> 1kHz). Except that, they have to work in rare gas atmospheres, in metal vapours or in more or less aggressive metal halide environments. Finally they are essentially involved in the breakdown process and the glow to arc transition from the cold to the thermally emitting electrodes. The actual operational condition of an electrode is the result of selfconsistent optimization processes, and it is not easy to influence and modify them by changing the boundary conditions. At the other hand, it is obvious that the definition of an optimum electrode condition is not easy considering the different phases of lamp operation. Thus, it is not surprising that experimental experience as well as trial and error are essential tools for the electrode design until now.

In contrast to the careful investigation of LTE plasmas in the sixties and seventies of the last century which produced a quantitative knowledge on transport properties, radiation properties and power balance of HID plasmas, the understanding of electrodes remained descriptively and qualitatively. The theoretical descriptions of WEIZEL, ECKER, BADE/YOS, NEUMANN and WEYMOUTH were careful and partially very detailed, but they suffered from a serious deficit of basic experimental information and, as a consequence, it was difficult to verify their conclusions.

In the last ten years SCHLAGER, MENTEL and coworkers, BOETTICHER and KETTLITZ and coworkers proposed new diagnostic tools and tested them successfully for the independent determination of the electrode temperature and its spatial distribution, the electrode loss power, the emission properties and work function and the cathodic and anodic voltage drop. These methods were very helpful to understand the behaviour and the response of the electrodes on changing operational conditions, and many predictions of the older and recent theoretical approaches were verified quantitatively.

The experimental conditions of the most nonindustrial research groups and the experimental pecularities of some of the diagnostic methods do not allow the use of metal vapours as discharge medium. Thus, most of the results are restricted to rare gas discharges, and the transfer to actual lamp operational conditions and atmospheres requires some modifications or simplifications which may be justified from a comparison with the rare gases measurements. Examples for the investigation of electrodes in mercury-sodium vapour and metal halide atmospheres are presented and the consequences are discussed.

Finally some open questions as the influence of gas mixtures having different ionization potentials on the power balance of the cathode or the influence of the electrode work function on the anodic power balance are discussed.