Abstract for ICAMDATA05, Meudon, France
October 15–19, 2006

The Role of Molecules in Low Temperature Plasmas for Lighting

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Domain : Lamps and Lasers

High intensity discharge (HID) lamps are low temperature (0.5eV), weakly ionized plasmas sustained in a refractory but light transmissive envelope for the purpose of converting electrical power into visible radiation [1]. For commercial applications this conversion must occur with good efficiency and with sufficient spectral content throughout the visible (380-780nm) to permit the light so generated to render colors in a fashion comparable to natural sunlight. These goals are often achieved by adding multiple metals to a basic mercury discharge. Because the vapor pressure of most metals is very much lower than mercury itself, chemical compounds containing the desired metals, and having higher vapor pressures are used to introduce the material into the basic discharge [2]. Complexing agents which further improve the vapor pressure are used to enhance the amount of metals in the discharge [3,4]. The metal compound and complexes are usually polyatomic species which vaporize and subsequently dissociate as they diffuse into the bulk plasma. Under the approximation of local thermodynamic equilibrium (LTE) the particles are in equilibrium, but not with the radiation field. Strong thermal (106K/m) and density gradients are sustained in the discharge. Atomic and molecular radiation produced in the high temperature core transits through colder gas regions before exiting the lamp. In these regions where the complex molecular species exists in an undissociated state, bound-free transitions can result in energy being effectively converted from light radiation into heat in the mantle. Bound-bound transitions in identifiable molecules can result in modification of the spectral output in unpredictable and counter-intuitive ways. Examples of complexing agents [5] and their effect on the spectral output of typical rare-earth containing HID lamps will be given. The melt composition and the complexing agents themselves may change with time, as chemical reactions in the lamp occur, and their benefit is accordingly altered. Optical absorption and emission data, molecular structure and electron impact and attachment cross section data on these molecular components is sparse [6] but necessary to understand lamp performance in the lamps re-ignition phase and during steady state operation. More data is needed.

[1] J. F. Waymouth, Electric Discharge Lamps, MIT, Cambridge, MA (1971).
[2] G. G. Lister, J. E. Lawler, W. P. Lapatovich and V. A. Godyak, Rev. Mod. Phys. 76, 541-598 (2004).
[3] R. Lorenz, Lighting Research & Technology, 8, 136-140 (1976)
[4] K. Hilpert, J. Electrochem. Soc. 136, 2099-2108 (1989).
[5] W. P. Lapatovich and J. Baglio, Proc. 9th Intl. Symp. On the Sci. and Tech. Of Light Sources, 026: I, Cornell U., Ithaca, NY (2001).
[6] A. Chrissanthopoulos, G. D. Zisi and G. N. Papatheodorou, Proc. 10th Intl. Symp. On the Sci. and Tech. Of Light Sources, P-042, 269, IoP Conf. Series 182, Toulouse, France (2004).