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Electron, Atomic, and Radiation Kinetics in Plasma Discharge Lighting: Advanced Models and Observations[1]

JOHN L. GIULIANI[2], Naval Research Laboratory

Non-LTE discharges used in lighting sources provide an excellent testbed for understanding the interplay between plasma, atomic, and radiation physics. Standard models for the Hg fluorescent bulb include non-equilibrium kinetics for the species, but employ both a 0-D Boltzmann equation for the electron distribution function (EDF) and Holstein's probability-of-escape for radiation transport. These assumptions overlook some of the more interesting, and challenging, aspects of plasma lighting. The radial ambipolar potential requires the inclusion of the spatial gradient term in the inhomogeneous electron Boltzmann equation. The resulting EDF is found to depend on both electron energy and radial position [1]. Advanced radiation transport techniques account for non-local photo-pumping, line overlap within the Hg resonance lines, and partial frequency redistribution [2]. The results of our completely coupled model match the observed spatial distribution of Hg excited states and the line-of-sight intensity [3]. Due to environmental initiatives there is also recent interest in non-Hg discharges for high intensity lighting. One example is an RF electrodeless Mo-O-Ar plasma discharge bulb which operates by recycling the emitting Mo with an O catalyst. Based on atomic physics calculations for Mo [4], the kinetic pathways leading to visible emission can be identified [5] and explain the measured lighting efficiency of ~40 lumens/watt of supplied power.

[1] J. Appl. Phys., 94, p.62, 2003.
[2] Plasma Sources Sci. Tech., 14, p.236, 2005.
[3] J. Phys. D., 38, p.4180, 2005.
[4] New J. Physics, 6, p.145, 2004.
[5] J. Appl. Phys., 95, p.5284, 2004.

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[2]Collaborators: G.M. Petrov, J.P. Apruzese, A. Dasgupta, and K. Bartschat.