Investigations of Degradation Phenomena in High Temperature DischargeLamps using Thermochemical Modelling

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ABSTRACT

Electrical lighting became a commodity in our daily life since the invention and spread of incandescent lamps at the end of the 19th century. Today, electrical light sources based on incandescent, gas discharge and solid state lighting are used for numerous application areas. The role of lamp research is an essential part with respect to further improvements of lamp performance such as light quality and efficiency. In gas discharge lamps physical and thermo chemical analysis and modeling is the basis for a continuous improvement of lamp performance and the development of new products. Physical and chemical properties of the lamps are strongly related to the overall life time behavior. Modeling tools are used to predict optimal lamp design parameters such as choice of discharge tube (burner) and electrode materials and their geometries, lamp fillings and operation mode. Complex chemical reactions such as corrosion and transport properties of lamp fillings, wall and electrode materials and interactions between these components need to be studied in order to realize stable lamp performance over lamp life. Combining physical and thermo chemical modeling tools with data from experimental analysis, finally results in an optimized design of real lamps.

Discharge vessels made of translucent polycrystalline alumina (PCA) are used for advanced metal halide lamps. These vessels contain a mixture of metal halide salts which partially vaporize under operating conditions. During the operation of a metal halide lamp, corrosion of the lamp burner due to chemical reactions between the wall material and the filling material can be observed. The operating conditions of the lamp result in steep temperature gradients with high absolute temperatures and pressures. It can be observed that the wall material PCA is dissolved at hot parts of the vessel and deposited at colder spots of the burner. To reduce the experimental effort and to achieve a better theoretical understanding of the phenomena causing these effects, computer-based model calculations are performed. The chemical transport of the wall material Al_2O_3 in metal halide lamps has an influence to the life time of these lamps. The chemical transport can be simulated using SimuSage® by implementing an algorithm, which is based on the cooperative transport model. A thermodynamic database establishes the base of the equilibrium calculations, which includes the thermodynamic data of lamp relevant species. Calculations have been performed varying temperature and composition of the salt.