[IV~8] [PDP]

Modeling of Rare-Gas/Xenon Plasma Display Panel Cell

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Abstract

In order to achieve high luminance, luminous efficiency and life-time requirements, we are using computer models to investigate rare-gas discharge physics and the time-dependent plasma dynamics of AC-PDP cells. A plasma chemistry model is used to investigate plasma reaction mechanisms occurring in a rare-gas/xenon filled plasma display cells. A one and two dimensional plasma transport model is used to investigate the dynamics of plasma operations in PDP Cells.

1. Introduction

The color AC plasma display panels have attracted much attention recently for its usage in high resolution screens and large size displays in next generation televisions. The AC-PDPs with its relatively simple structure have demonstrated inherent memory function, high gray level and good color quality. However, current AC-PDPs have to be improved in its luminance, luminous efficiency and life-time requirements to be a successful commercial product. To accomplish those goals, we need to understand the detailed dynamics of glow discharges in AC-PDPs.

A plasma chemistry model is used to investigate generation and destruction mechanism of UV producing states in a rare-gas/xenon filled plasma display cells. The essence of the discharge characteristics are properly captured with the incorporation of the circuit model and boundary conditions. A one and two dimensional plasma transport model is used to investigate and optimize the efficient operations of AC-PDP cells. Comprehensive energy levels of helium, neon and xenon, and electron impact and heavy particle reactions are included in the model to investigate the excitation and deexcitation mechanisms for UV radiating states. Various mixtures of rare-gases are used in the model to develop a strategy to maximize UV production from the rare-gas discharges. A Boltzmann code is used to obtain the electron energy distribution function and electron impact rate constants. Electron and ion drift and diffusion loss equations are included as well as secondary electron emission from the electrodes. Charge conservation includes bulk and surface charges of the cell.

2. Description of Plasma Display Cells

Plasma display cells operate on light emissions by gas discharges as in fluorescent lamps. In AC color plasma display cells, UV photon emissions from xenon atoms are converted to visible light by the use of appropriate phosphors coated on the walls of the display cells. Two plane electrode PDPs are one of the simplest devices (Thompson Type). Lately, multielectrode PDPs are becoming popular (Fujitsu Type). In these devices, gas gap is 100's of microns in length with the MgO protection layer. The fill pressure ranges from about 0.5 to 1.0 atm. The discharges voltages range from 50 to 200 Volts.

3. Rare-Gas Plasma Physics

Rare-gases have been used as a primary fill gases for many plasma devices due to its inherent inert nature. Such devices range from lasers to high power pulse power devices. Based on previous research, it is known that the discharges of various rare-gas mixtures exhibit distinctly different physical characteristics. For example, electro-ionization effect has been seen in a discharge with Ar/Xe mixture but not in a He/Xe mixture. Therefore, lasers with a Ar/Xe mixture have shown much better efficiency than with a He/Xe mixture.[1] For AC-PDP cells, all the critical characteristics such as color purity, luminance, efficiency, and life-time must meet the desired engineering requirements to be a successful commercial product. Thus, it provides us with complex optimization problem.

To understand rare-gas discharges, an extensive set of rare-gas cross sections was obtained previously for the rare-gas laser modeling. A point kinetic Boltzmann code[2] using two term spherical harmonic expansion is used to obtain the electron energy distribution function, electron impact reaction rates and other parameters such as collision frequency, mean electron energy, and drift velocity. For this Boltzmann calculation, the local field approximation is assumed.

4. Plasma Chemistry Model

The value of a zero dimensional plasma chemistry model is its ability to test out complex plasma reactions in a computationally efficient manner. A gas discharge is very sensitive to various internal and external plasma parameters. The number densities of the UV generating excited state are very sensitive not only to the electron impact excitation from the ground state but also electron impact excitations and deexcitations from all other excited states and collisional deexcitations with other neutrals. Knowing the mechanisms which affect the UV producing states for various operating conditions is the key to understand the issues of luminous efficiency and luminance.

5. Multidimensional Plasma Transport Model

The model consists of a set of fluid equations for both electrons and ions, solved self-consistently with Poisson's equation. The code is capable of resolving sheaths at walls with sufficiently small grid resolutions. Ion are assumed to be isothermal and near neutral species temperature, so that ion motion is governed by the equations of continuity and momentum conservation. Electrons are assumed to be inertialess with a net velocity resulting from a near balance between drift and diffusion. Electron motion is governed by equations for continuity and energy conservation. [3]

6. Summary

Utilizing a plasma chemistry model and a plasma transport model, we were able to capture the important discharge characteristics of the AC-PDP cells and aid the optimization of luminance, efficiency of AC-PDP cells based on plasma parameters.

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References

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