OPTIMIZATION OF A PLASMA DISPLAY PANEL CELL

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AGENDA

- Introduction
- Description of the plasma display panel (PDP) model
- Simulation of a coplanar-electrode PDP cell
- Effect of gas pressure, He/Ne ratio and dielectric spacing
- Conclusions
INTRODUCTION

- Computational models can be very useful for optimizing PDP performance as a function of gas composition, operating conditions, materials and cell design.
- We have developed a 2-dimensional hybrid PDP simulation for this purpose.
- The model has been used to investigate the operation of a coplanar-electrode PDP cell with He/Ne/Xe gas mixtures.
- PDP cells have been found to operate more efficiently at higher pressures due to more efficient production of $\text{Xe}_2$.
- Gas mixtures with higher Ne concentrations produce more visible light photons with similar efficiency.
- PDP characteristics are very sensitive to dielectric spacing, and there is an optimum spacing where light emission and light generation efficiency are both high.
- In this talk, I will describe the model, use computational results to explain the operation of the PDP cell and present results from parametric studies.
THE PLASMA DISPLAY PANEL MODEL

- The PDP simulation code consists of a number of modules in which different physical quantities are computed using the appropriate computational techniques.
DESCRIPTION OF THE MODEL

- The main model consists of:
  (1) Poisson’s equation,
  (2) continuity equations for charged species,
  (3) equation for dielectric charging,
  (4) continuity equations for neutral species.
- Equations (1)-(3) are solved using implicit time integration.
- The electron transport models include:
  - implicit solution of the electron energy conservation equation for $T_e$,
  - local field approximation,
  - a Monte Carlo simulation for secondary electrons.
- The plasma model is coupled to a radiation transport model for computing visible light emission and an external circuit model.
The base case has been studied for He/Ne/Xe = 70/26/4, 400 Torr, and $V_o = 200$ V.
The applied voltage on E2 initiates a discharge in the gas.

Electrons and ions charge the dielectric surfaces under E1 and E2, which reduces the gap voltage and extinguishes the discharge.
ELECTRON AND Xe\textsuperscript{+} DENSITY (SECOND PULSE)

• The electrons drift to E2, the positively biased electrode, and the ions drift towards E1.

• The ion density decays much slower after the discharge than electron density because of smaller ion mobility.
Visible light is produced when UV photons generated by Xe*, Xe** and Xe2* bombard the phosphor.

The cell keeps on emitting visible light for many microseconds after the discharge because of long lived Xe metastables.

UV emission from Xe* and Xe** is optically thick and UV photons from only a few absorption lengths of the phosphor contribute to visible light emission.

Since radiation from Xe2* is optically thin, it contributes more strongly to visible light emission.
EFFECT OF GAS PRESSURE

- As pressure increases, the discharge sustaining voltage becomes larger, the discharge duration reduces and less energy deposition takes place.
- However, higher pressures lead to more visible light generation since \( \text{Xe}_2^* \) producing three-body reactions are more efficient.
- PDP cell, therefore, operates more efficiently at higher pressures.

- \( V_1 = 0 \text{ V}, V_2 = 200 \text{ V}, \text{He/Ne/Xe} = 70/26/4 \)
EFFECT OF He/Ne RATIO

- As He concentration is decreased, the PDP cell spends more time in the discharge phase because of a lower sustaining voltage, which increases light emission.

- Larger total current fluence at smaller He concentrations leads to more energy deposition.

\[
V_1 = 0 \text{ V}, \quad V_2 = 200 \text{ V}, \quad \text{Xe} = 4\%
\]
At smaller discharge gaps, the bottom address electrode interferes with normal PDP operation.

Once the PDP is operating normally, discharge gap does not have a significant influence on total energy deposition.

There is an optimum value for the discharge gap at which efficiency and light intensity are both high.

- $V_1 = 0 \text{ V}$, $V_2 = 200 \text{ V}$, He/Ne/Xe = 70/26/4, 400 Torr
The reduction in light intensity at larger gap lengths is due to the fact that Xe\(^-\) density decays rapidly from the region of generation (near the top dielectric) to the phosphor (on the bottom dielectric) due to quenching.

Since UV radiation from Xe\(^-\) is optically thick, it decreases considerably as gap length is increased.
CONCLUSIONS

- A 2-dimensional hybrid model has been developed for plasma display panel (PDP) simulation.
- The model was used to simulate a coplanar-electrode PDP cell with He/Ne/Xe gas mixtures.
- PDP cells were found to operate more efficiently at higher gas pressures due to more efficient production of Xe$_2^\cdot$.
- Gas mixtures with higher Ne concentration produce more visible light because:
  - the discharge is sustained for a longer time,
  - three-body collisions (that generate Xe$_2^\cdot$) are more efficient with Ne than He.
- PDP light emission characteristics are very sensitive to dielectric spacing, and there is an optimum spacing where visible light emission and light generation efficiency are both high.