51st Annual Gaseous Electronics Conference
Maui, Hawaii
October 19-23, 1998

OPTIMIZATION OF A PLASMA DISPLAY PANEL CELL

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*Work supported by LG Electronics Inc. and NSF.

AGENDA

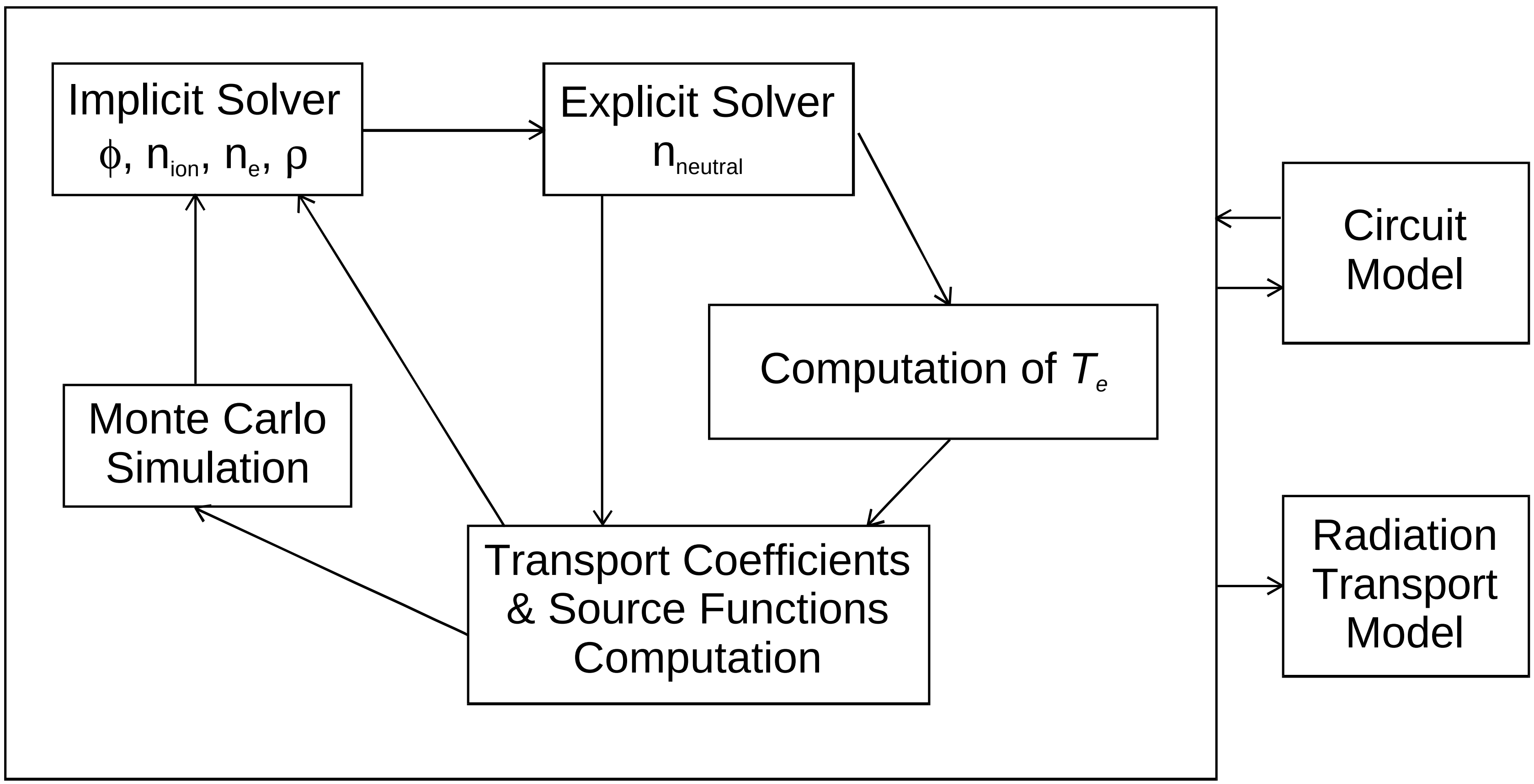
- Introduction
- Description of the plasma display panel (PDP) model
- Simulation of a coplanar-electrode PDP cell
- Effect of gas pressure, He/Ne ratio and dielectric spacing
- Conclusions

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 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,

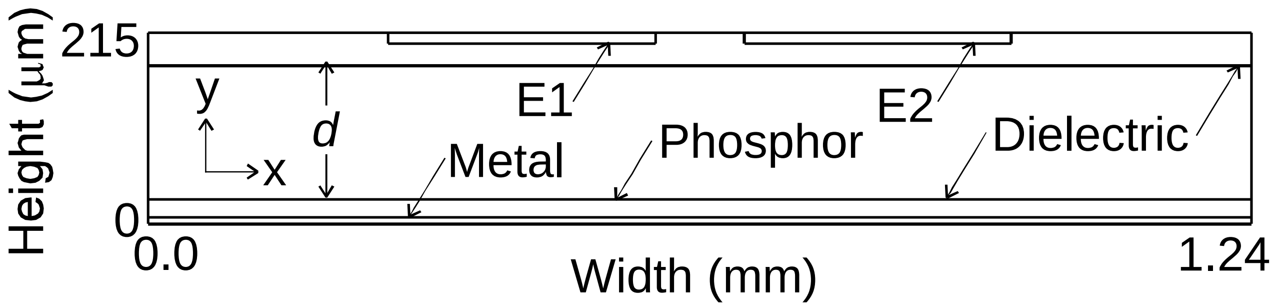
  (3) equation for dielectric charging,

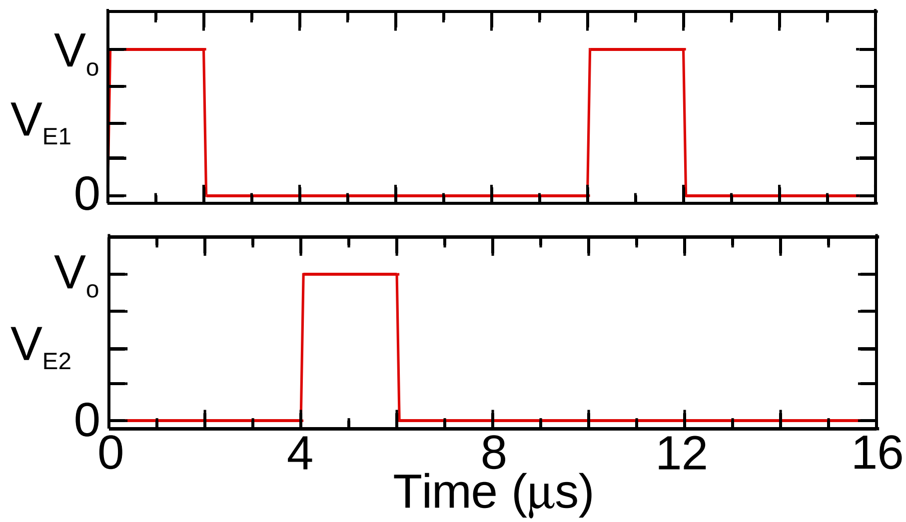
  (4) continuity equations for neutral species.

- 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.

BASE CASE OPERATING CONDITIONS

- The base case has been studied for He/Ne/Xe = 70/26/4, 400 Torr, and V_o = 200 V.





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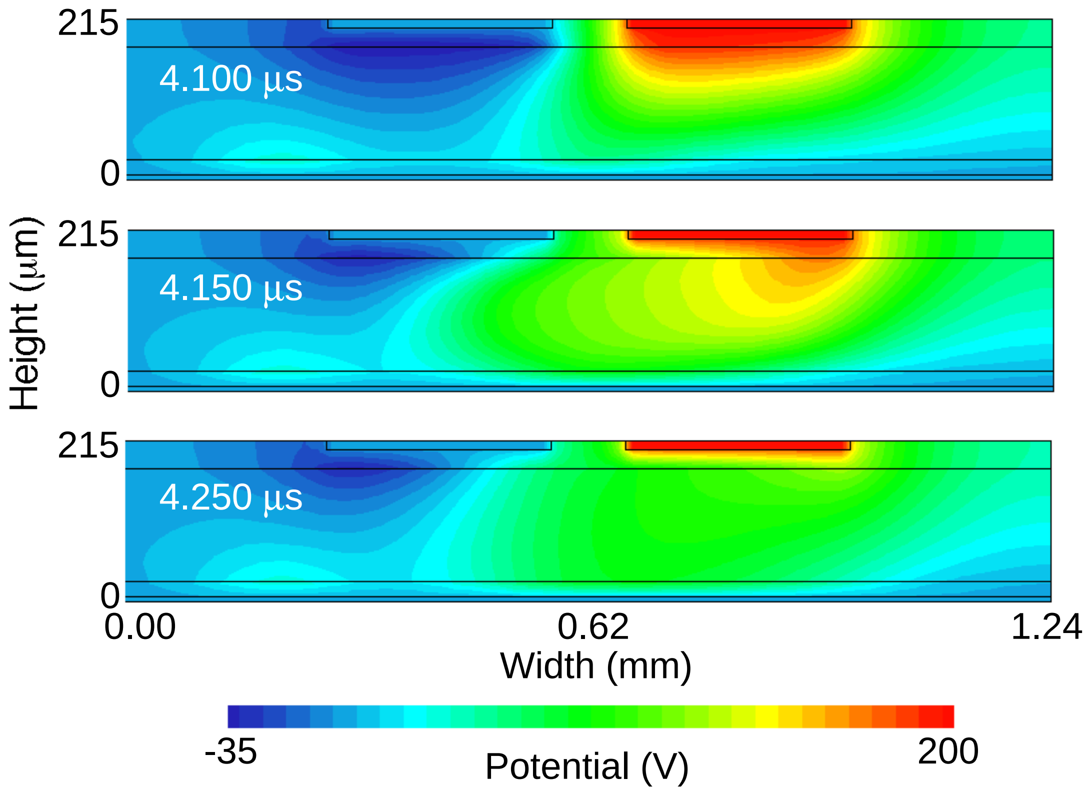
ELECTRICAL POTENTIAL (SECOND PULSE)

- 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.



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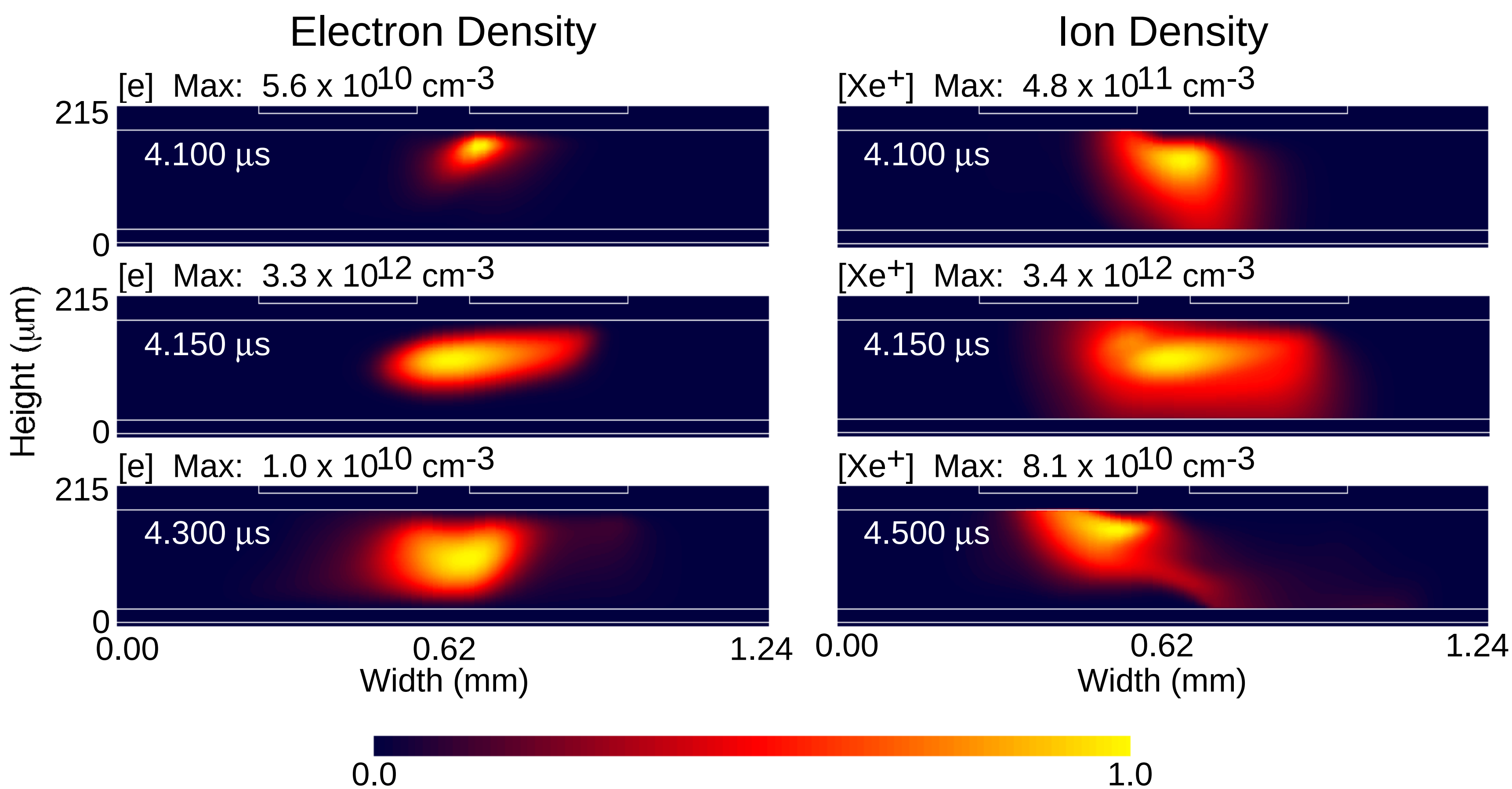
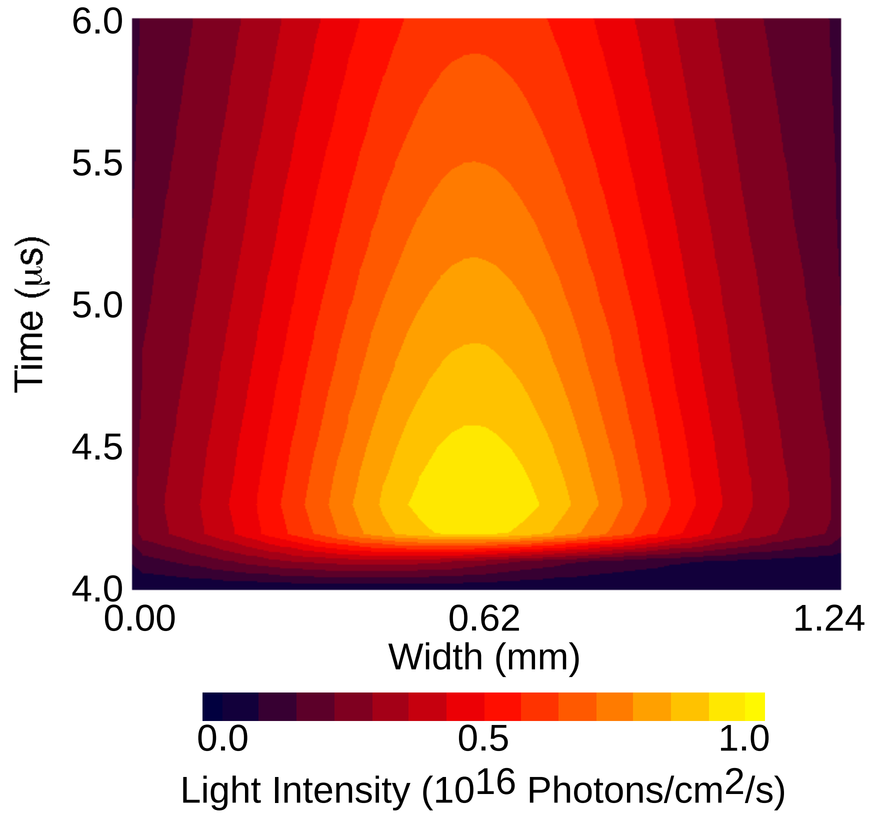
ELECTRON AND Xe^{+} DENSITY (SECOND PULSE)

- 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 EMISSION (SECOND PULSE)

- Visible light is produced when UV photons generated by Xe^*, Xe^{**} and Xe_2^* 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 Xe_2^* is optically thin, it contributes more strongly to visible light emission.



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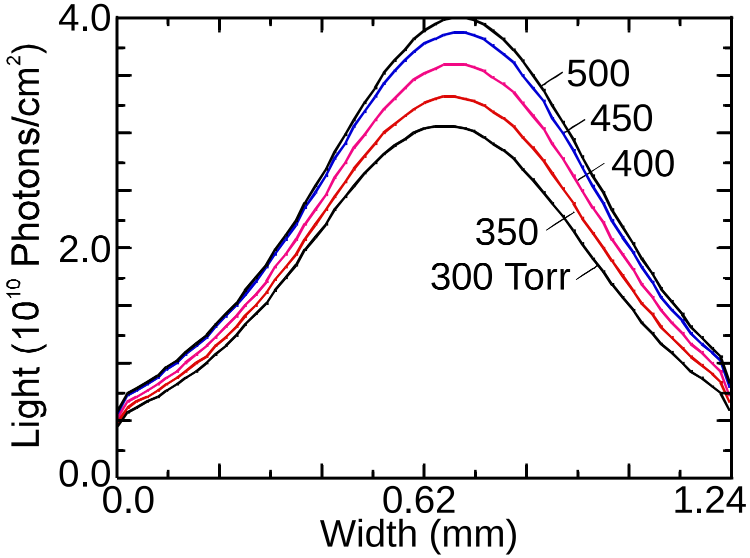
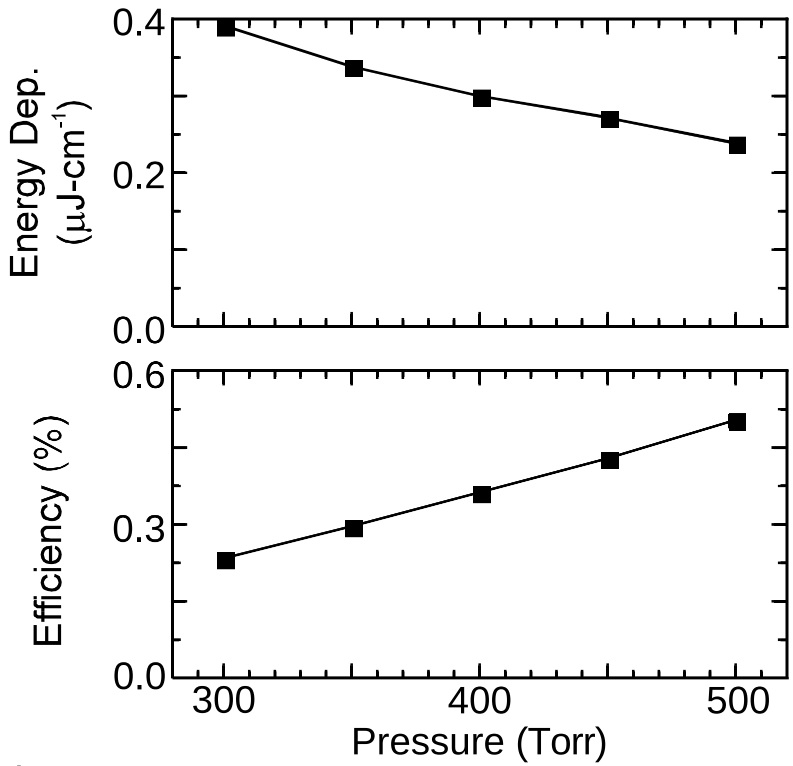
EFFECT OF GAS PRESSURE

- 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 Xe_2^* producing three-body reactions are more efficient.
- PDP cell, therefore, operates more efficiently at higher pressures.

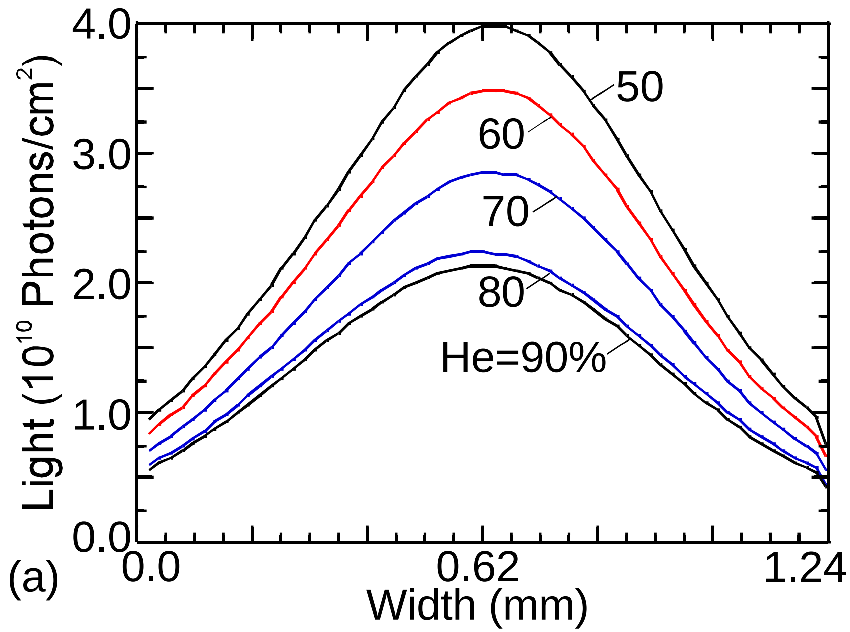


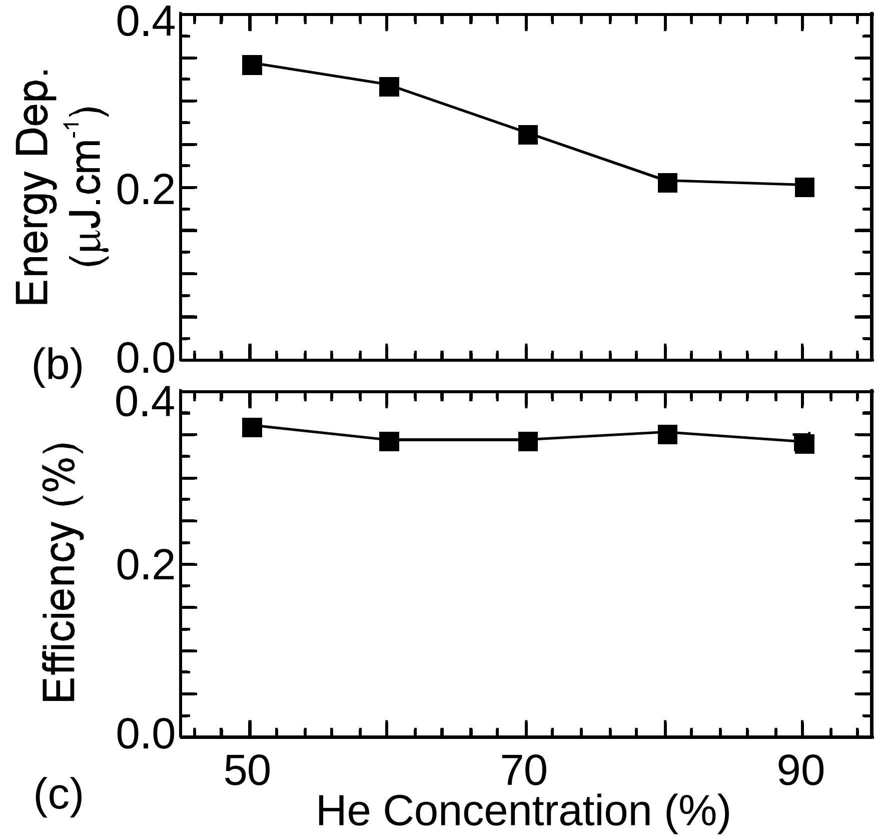


- V_1 = 0 V, V_2 = 200 V, He/Ne/Xe = 70/26/4

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.

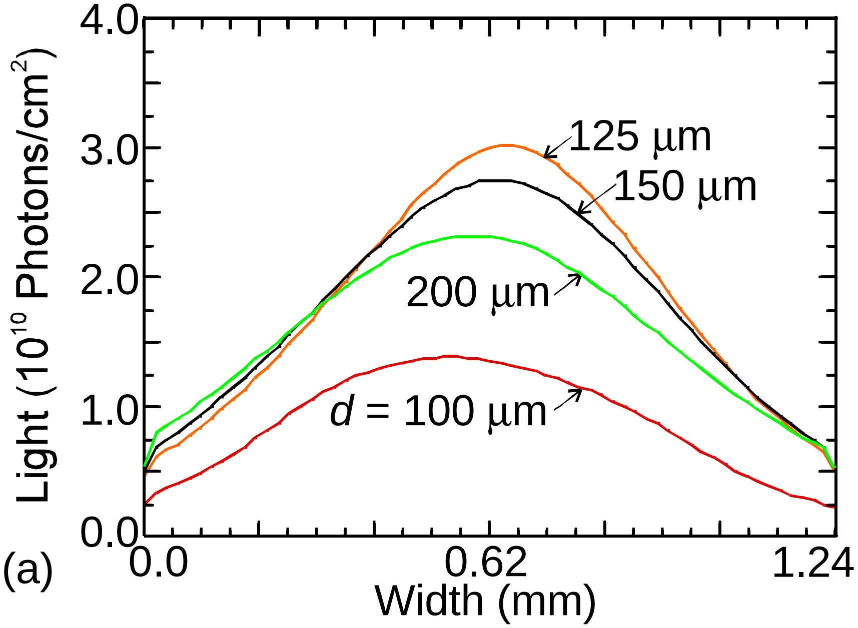




- V_1 = 0 V, V_2 = 200 V, Xe = 4%

EFFECT OF DISCHARGE GAP - I

- At smaller discharge gaps, the bottom address electrode interferes with normal PDP operation.
- Once the PDP is operating normally, discharge gap does not has 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.



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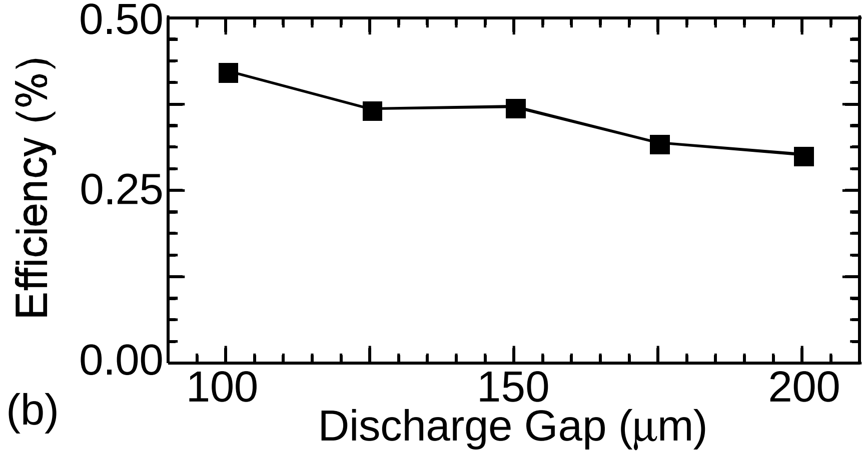

(b)

- V_1 = 0 V, V_2 = 200 V, He/Ne/Xe = 70/26/4, 400 Torr

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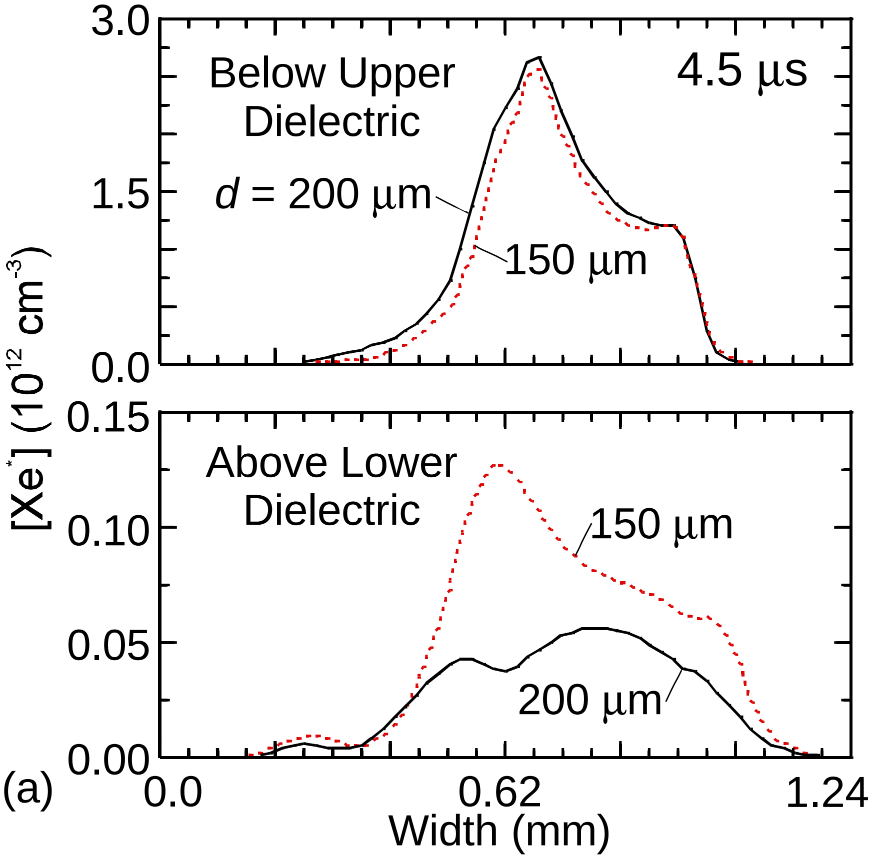
EFFECT OF DISCHARGE GAP - II

- 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.



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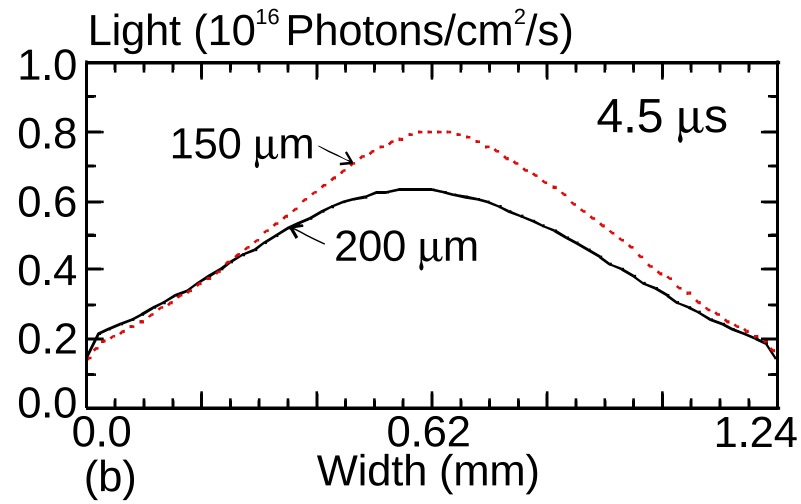

(b)

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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^*.
- 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^*) 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.