Pulsed and RF glow discharge in Helium atmosphere

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Outline

- Motivation
- Introduction : Dielectric Barrier Discharge(DBD)
- Experimental work
- Results
- Conclusion

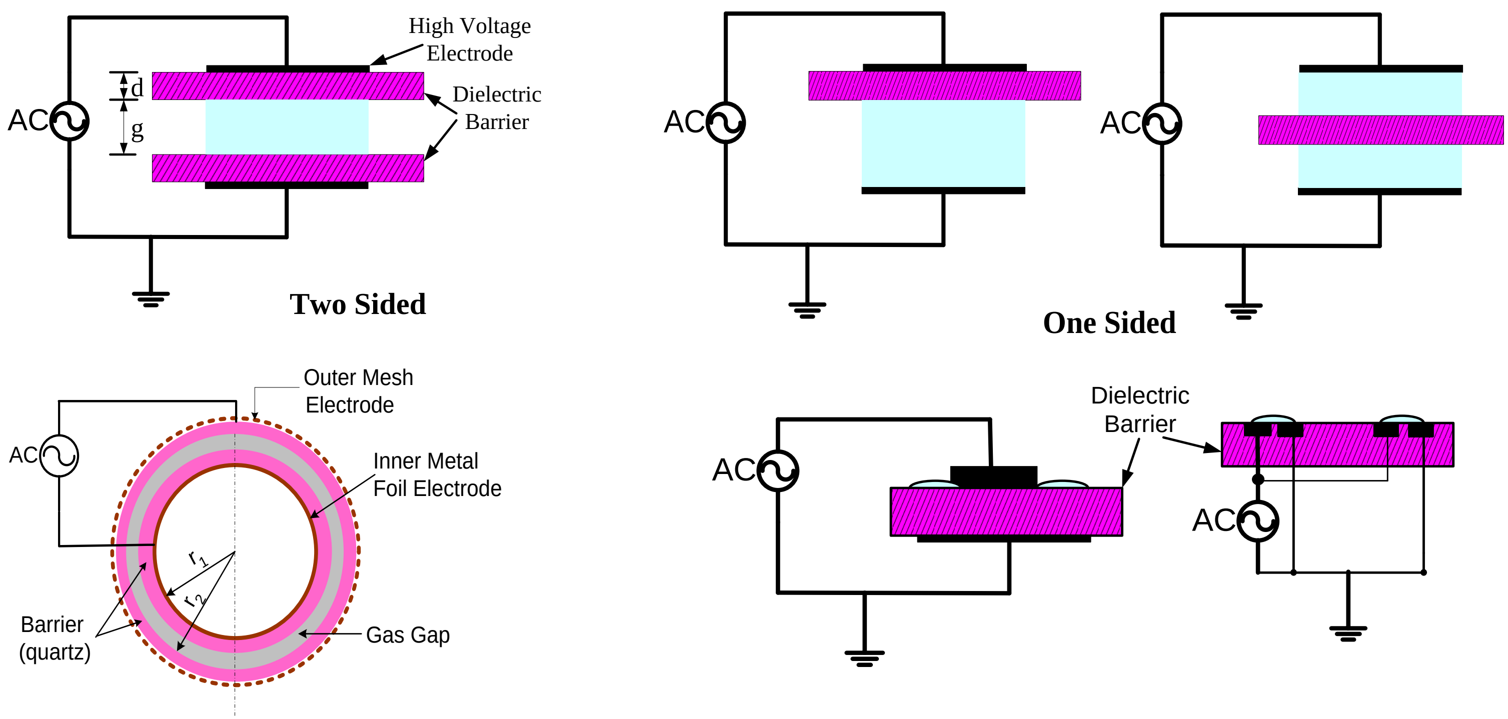
Motivation

- To investigate and analyze the characteristics of discharge patterns occurring in the volume discharge (VD) configuration of DBDs filled with helium gas for different waveforms.
- To analyze the dependency of the electrical to VUV/UV conversion efficiency on applied voltage waveform.

Introduction to DBD….

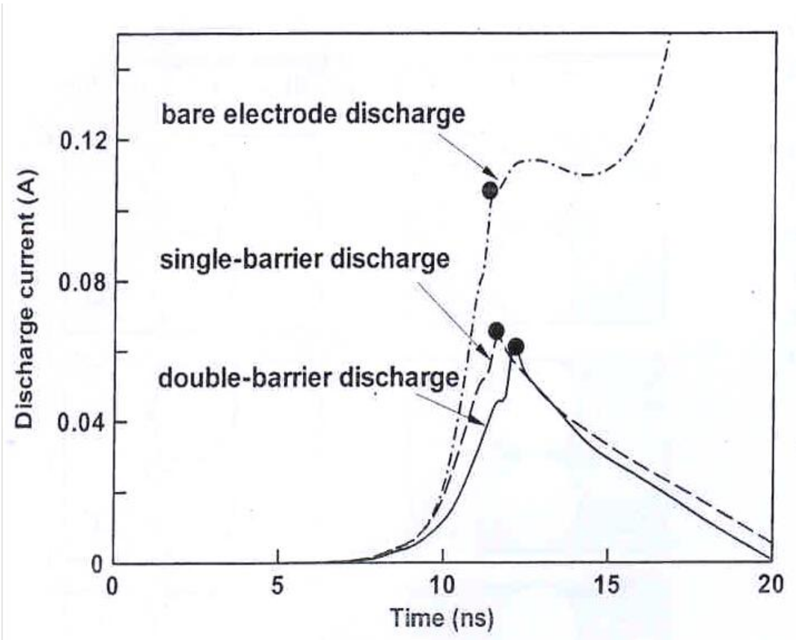
- Dielectric barrier discharges (DBDs), also known as silent discharges or barrier discharges, are generated in discharge configurations with at least one dielectric barrier between the electrodes.
- Dielectric Barrier Discharge (DBD) was originally developed in 1857 by *Werner von Siemens* as a method of ozone production.
- Andrews and Tait, in 1860, proposed the name ‘‘silent discharge,’’ because there is no transition from glow to arc and this is a glow discharge even at the atmospheric pressure.

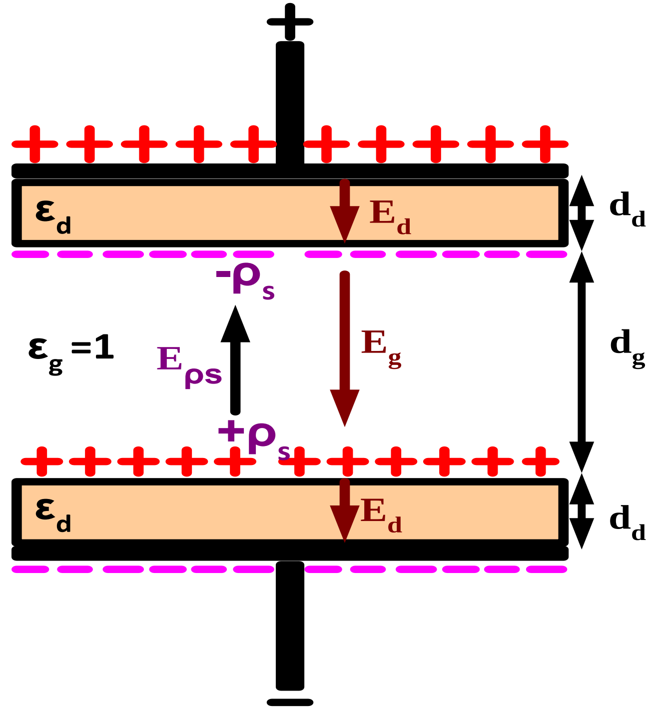
Possible DBD Geometries



(i). Volume discharge, (ii). Surface discharge (iii). Coplanar discharge

Typical dielectric barrier discharge configurations



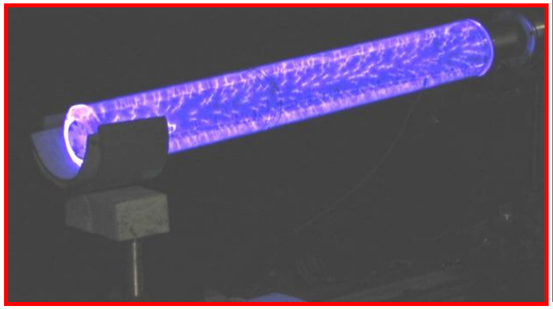
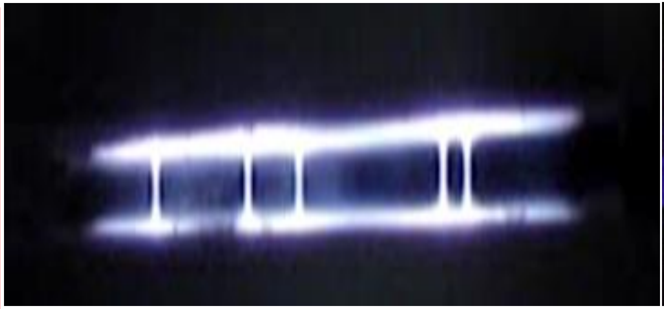
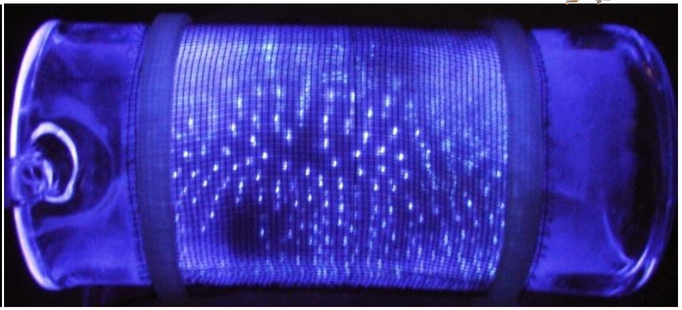


Role of Dielectric layers:

- It acts as current limiter and limits the discharge transition from glow to arc.

Generation Mechanism and thermal properties:

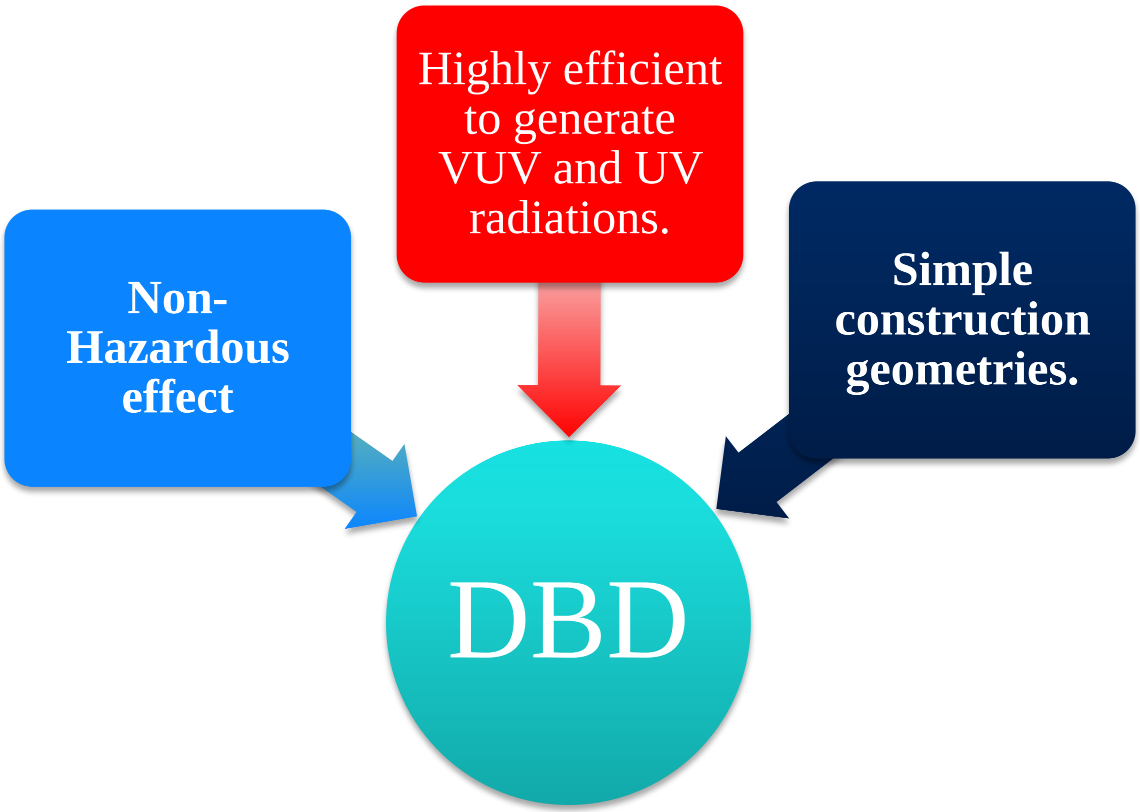
- AC/Pulse power supply is used for excitation of discharge .
- DBD is a non-equilibrium, non-thermal gas discharge phenomenon.

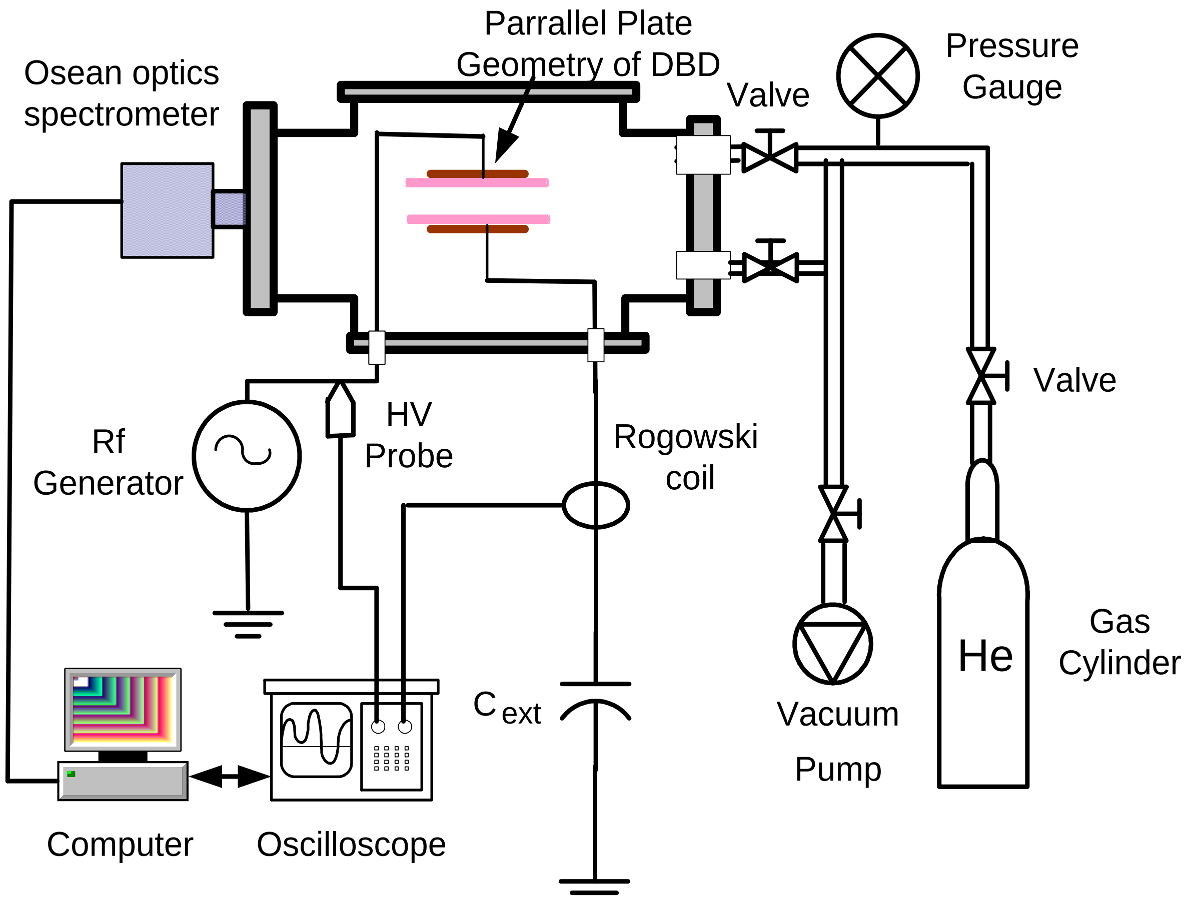
Electrical and geometrical Properties:

- When breakdown occurs, very short time duration micro discharges appear in a large number occurring discretely in space and time.
- Usually DBD exist in filamentary mode, based on streamer nature of discharge.
- Width of discharge gap: 0.1 mm to 100 mm and applied frequency below line frequency to several GHz.
- DB materials: quartz, glass, ceramics and also thin enamel or polymer coatings on metal electrodes.

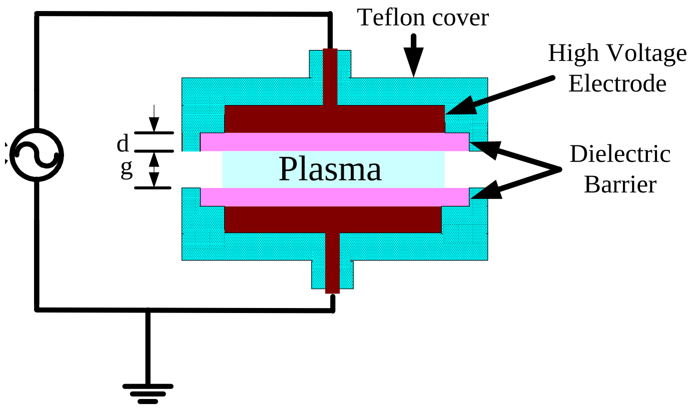
Key Importance of DBD



Experimental Setup



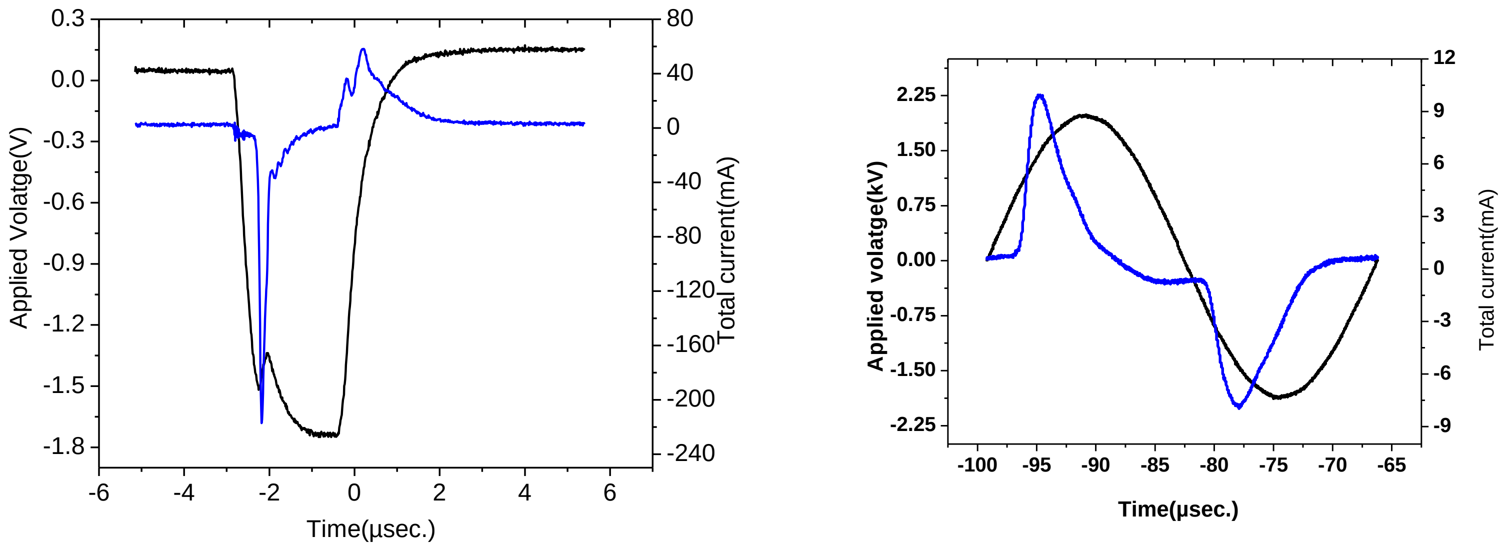
Geometrical Design



- Thickness of upper barrier =1 mm
- Thickness of lower barrier = 1 mm
- Electrode diameter =36 mm
- Electrode Thickness = 1mm
- Gas gap = 2 mm
- Dielectric Material Used= Quartz
- Pressure of Gas=100mbar
- Gas Used = Helium

Dielectric barrier capacitance
$C_{d1} = C_{d2} = 20.48$ pF

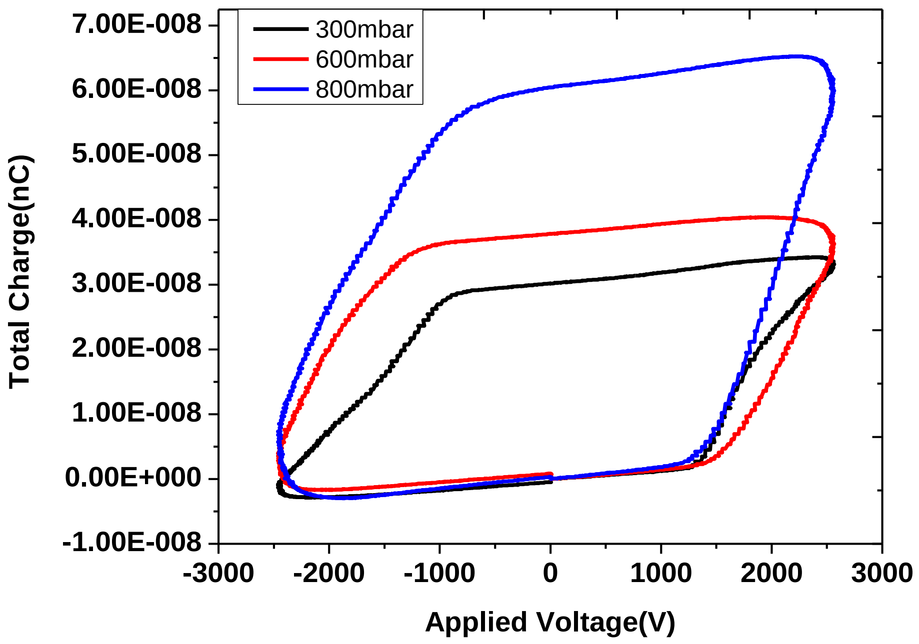
Experimental Results



(a) (b)

V-I waveforms at 600mbar and 30kHz using (a) Pulse (b) Sinusoidal waveform

Contd…

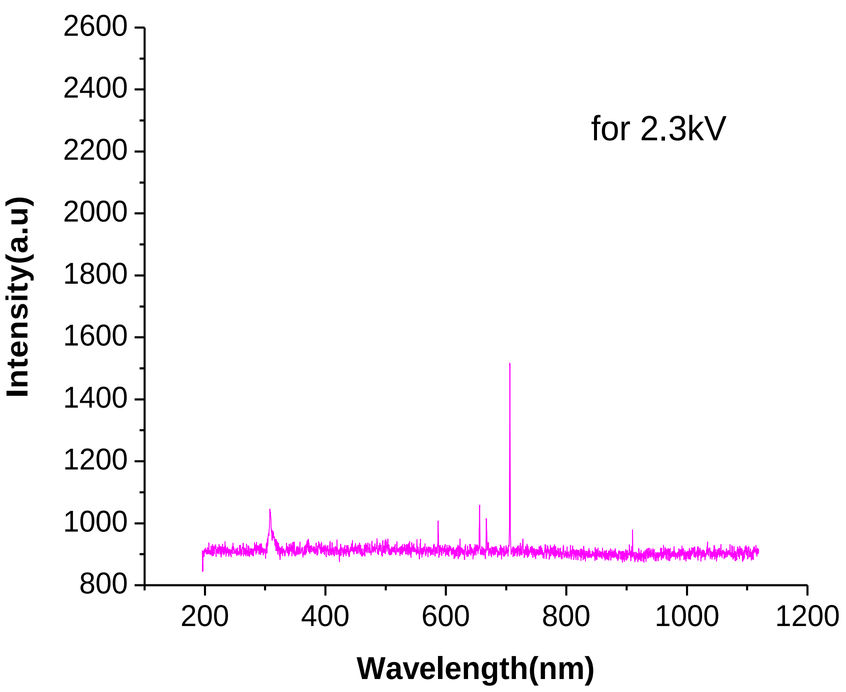


Lissajous $V - Q$ diagram of the Helium DBD in the case of three different pressures at 30 kHz for sine wave

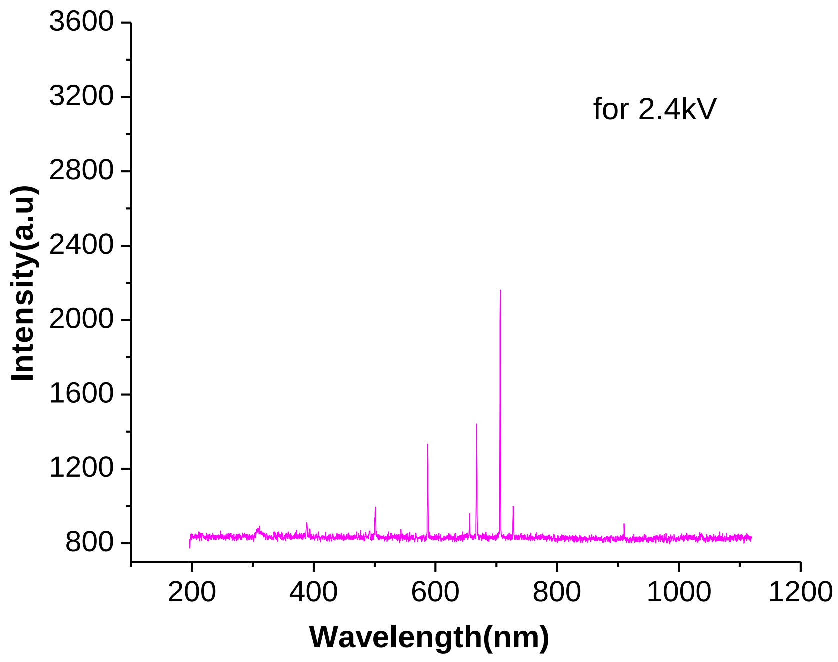
Study of emission spectrum

He Lines in Visible Range(nm)

388.8, 396.4, 471.3, 492.1, 501.5, 587.5, 667.8, 706.5, 728.1

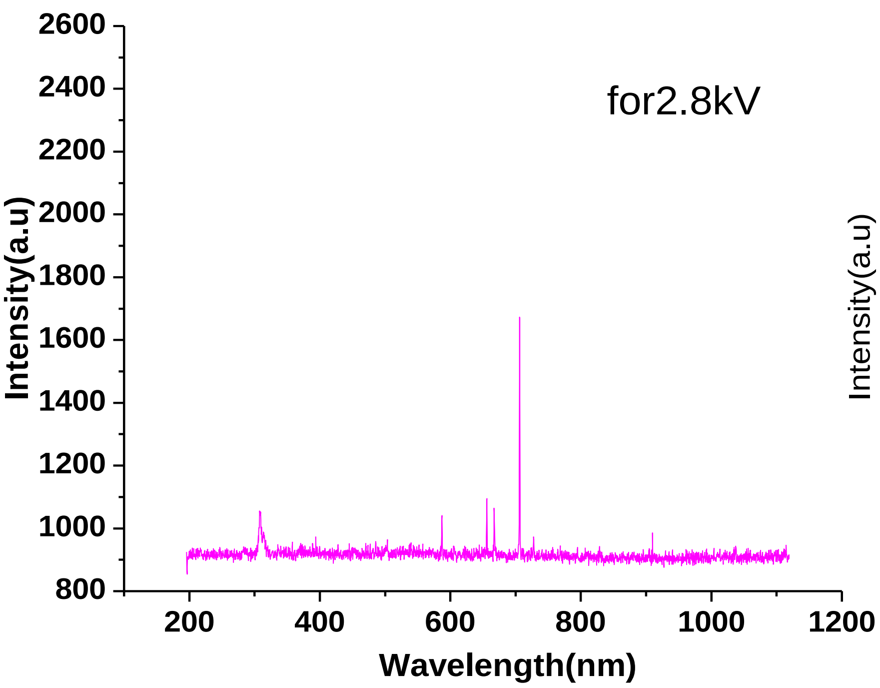


Using Sinusoidal waveform

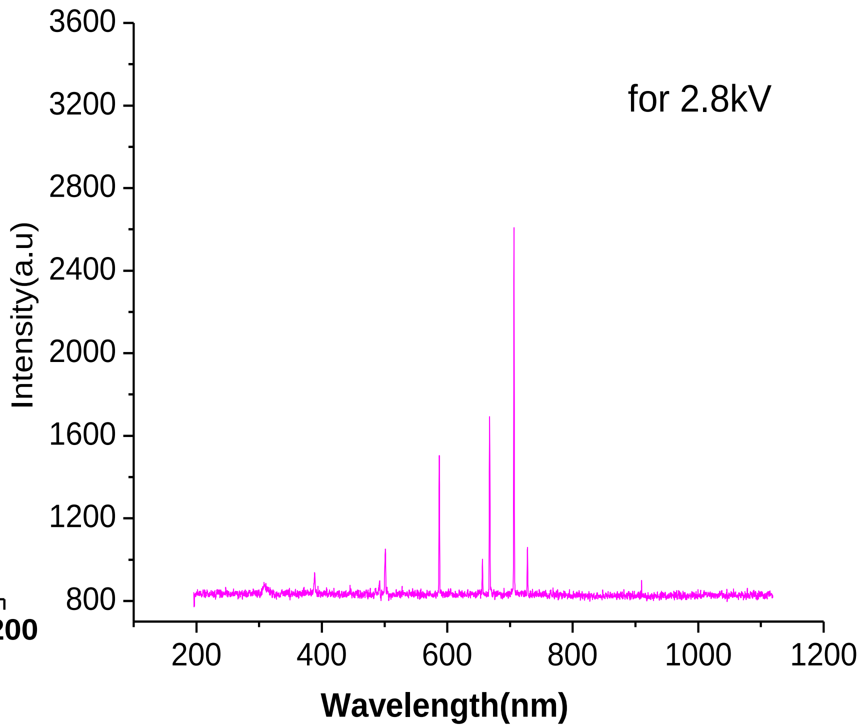


Using Pulsed waveform

Contd……

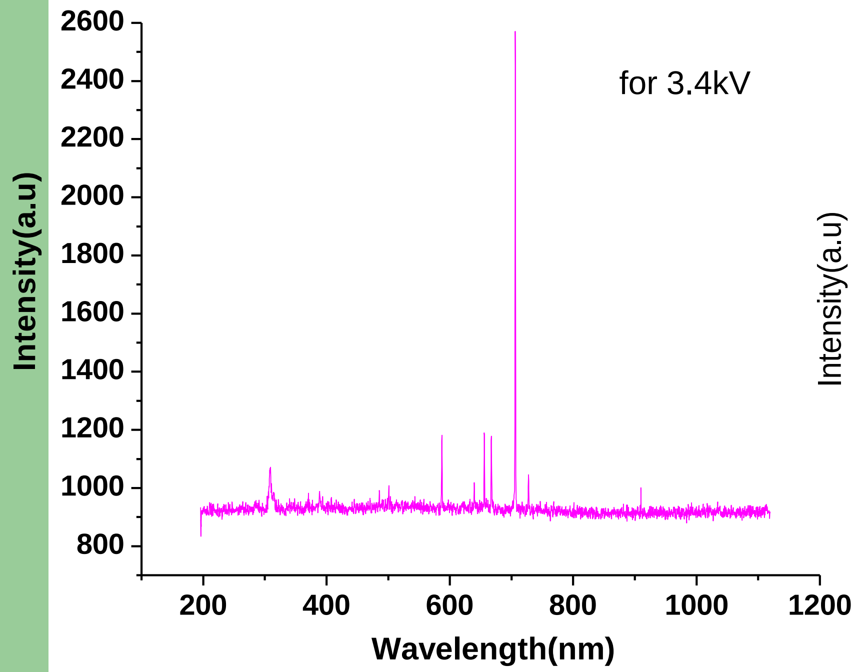


Using Sinusoidal waveform

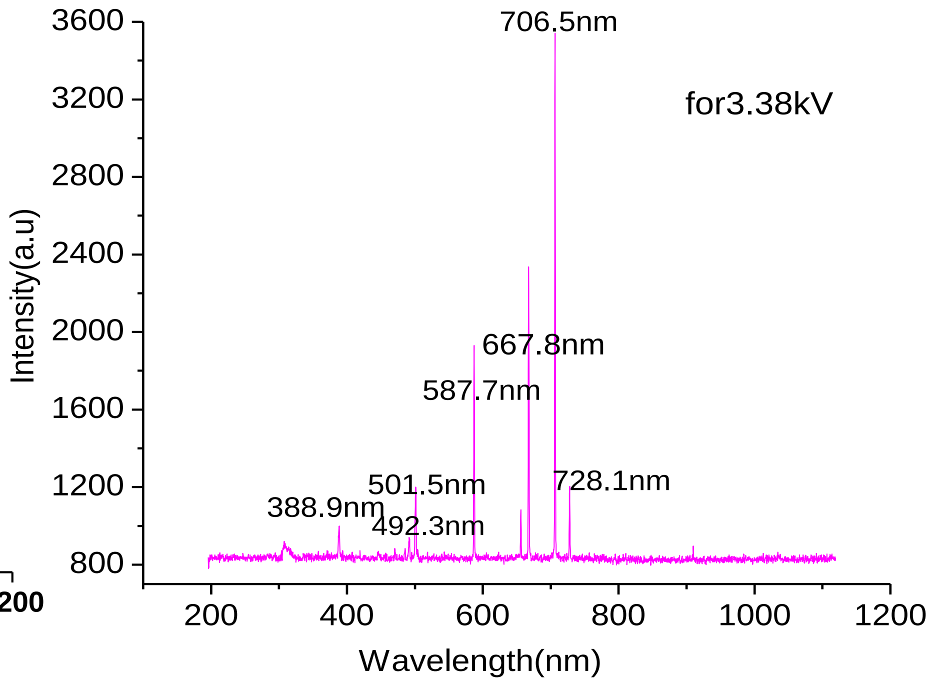


Using Pulsed waveform

Contd……

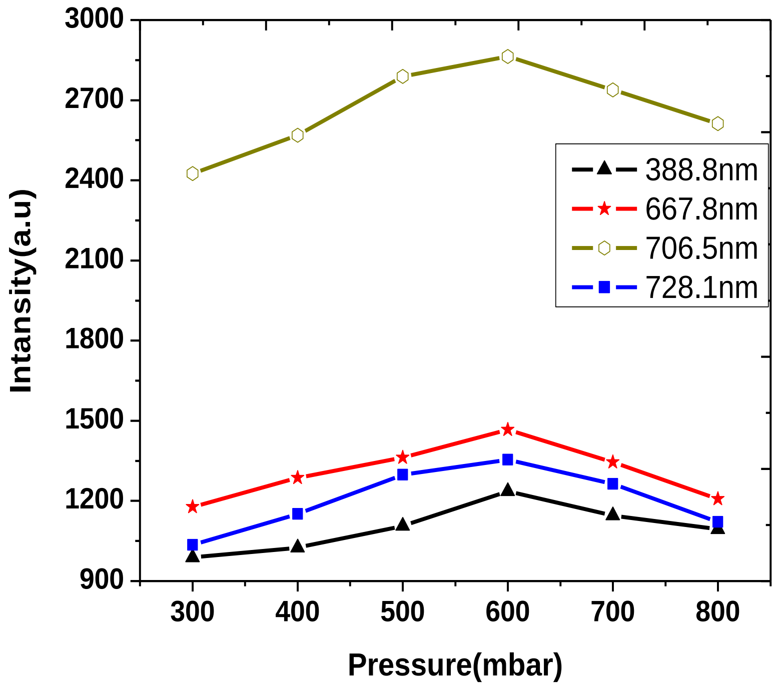


Using Sinusoidal waveform

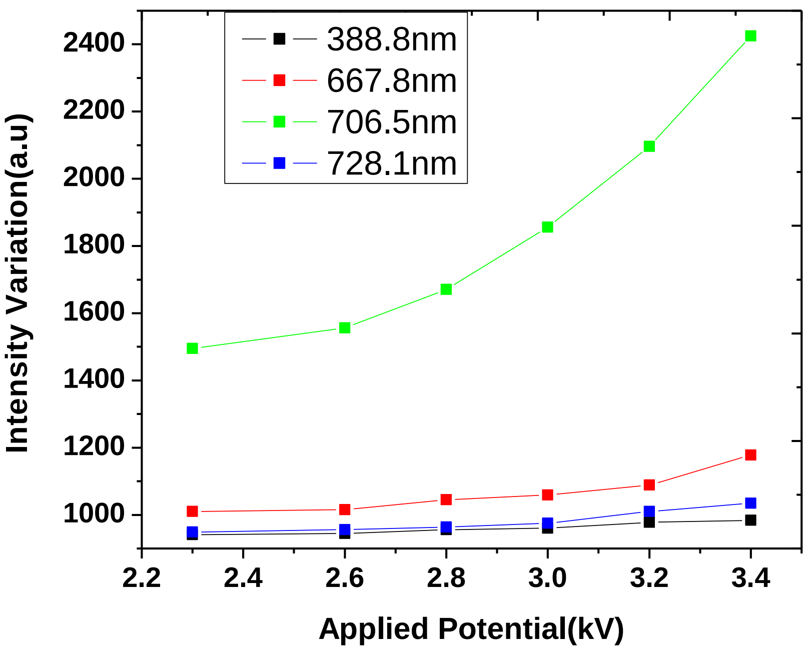


Using Pulsed waveform

Emission Intensities Variations

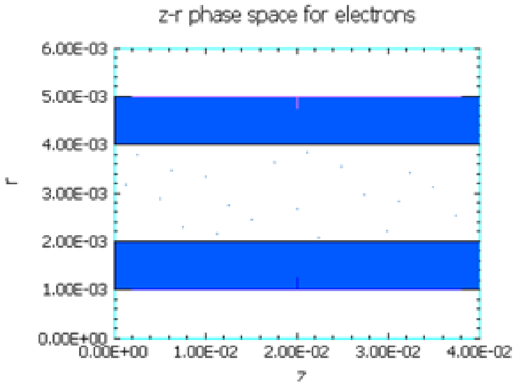


Intensities of different emission lines Vs. Pressure using pulse waveform

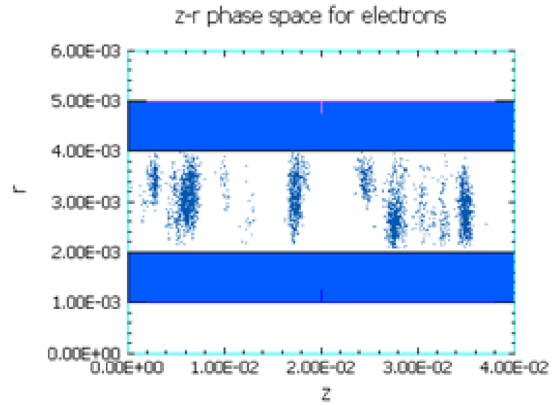


Intensities variation of emission lines Vs. applied potential sinusoidal Waveform

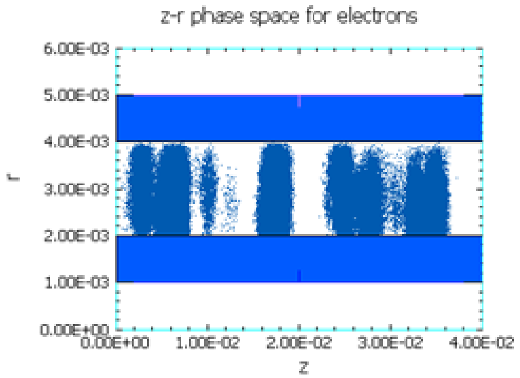
Kinetic Simulation using PIC Code



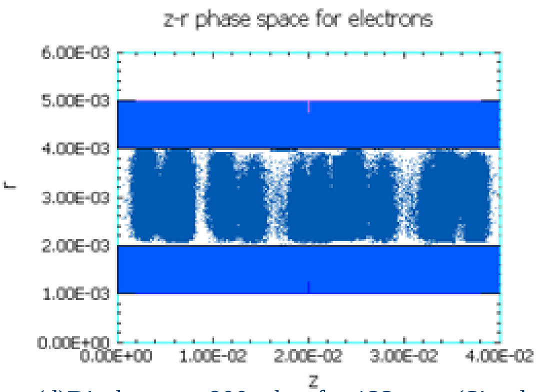
(a)DBD configuration without discharge with the initial electrons



(b)Discharge at 300 mbar for 123nsec. (Simulation time)



(c)Discharge at 600 mbar for 123nsec. (Simulation time)



(d)Discharge at 800 mbar for 123nsec. (Simulation time)

Conclusion

- The homogeneous type of discharges have been observed in helium DBD at different operating conditions.
- Kinetic simulation confirms that electron concentration is continuously increasing with the increased gas pressure for the same simulation time.
- Pulse excitation deposited more power so the more current and highly intense spectral lines of helium discharge for the same repetition rate as for the sinusoidal waveform.

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Thank you
for your attention