

# A Compact Excimer Lamp Constructed by Piezoelectric Transformer

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Typical application of piezoelectric transformer (PT).

Our proposal: Discharge plasma generations using the PT.

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Method of VUV detection using a phototube.

## ● **Experimental results**

Detection of the VUV radiation.

VUV radiation characteristics.

## ● **Summary**



# Background of this study

## ➤ **Piezoelectric transformer (PT): High-voltage generator**

Material: Lead zirconate titanate ceramics  $\text{Pb}(\text{Zr}, \text{Ti})\text{O}_3$ , (PZT)

Ferroelectric material

Principle: Interactive electro-mechanical energy conversion  
(Piezoelectric effect)

## ➤ **Advantages**

Compact, High efficiency, Low-noise, safety

## ➤ **Applications**

### ● **Backlight inverter of liquid crystal displays (LCDs)**

- ◆ Notebook computer
- ◆ Mobile phone
- ◆ car navigation systems

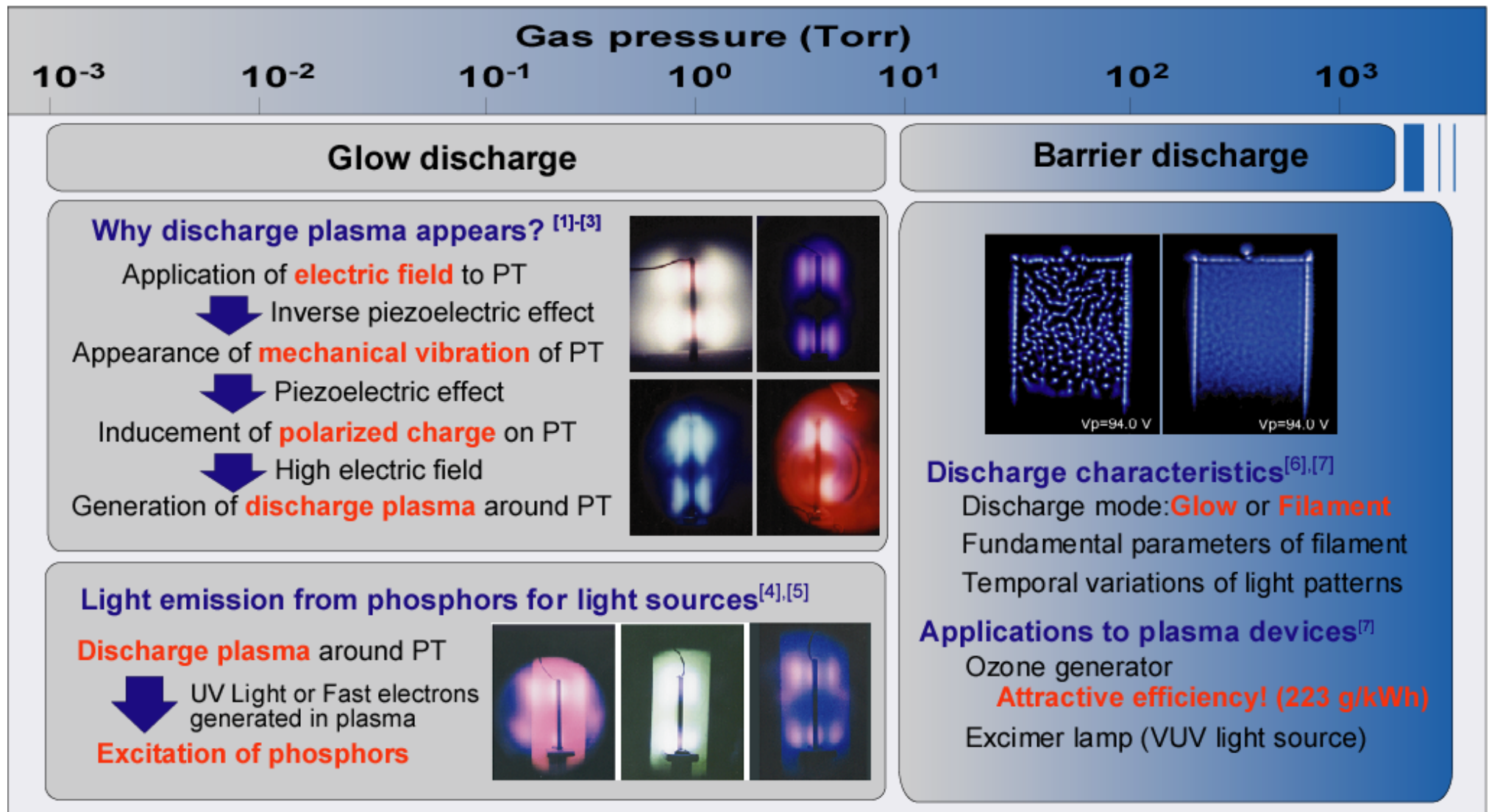
### ● Copy machine, Ion generator and ozonizer (corona type)



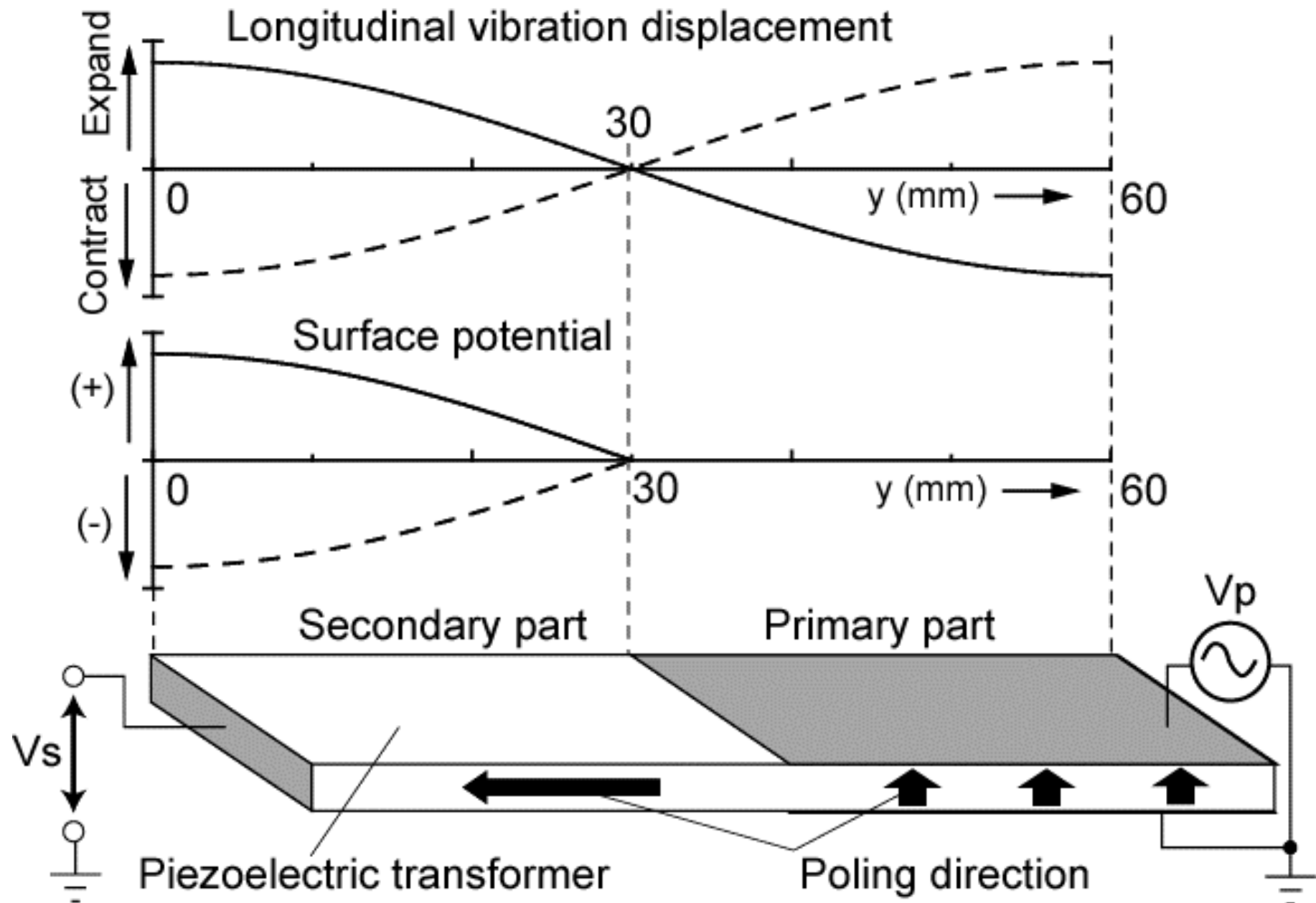
# PT-based Plasma Reactors

Direct generation of discharge plasma on the ferroelectric material surface inducing high-voltage due to piezoelectric effect

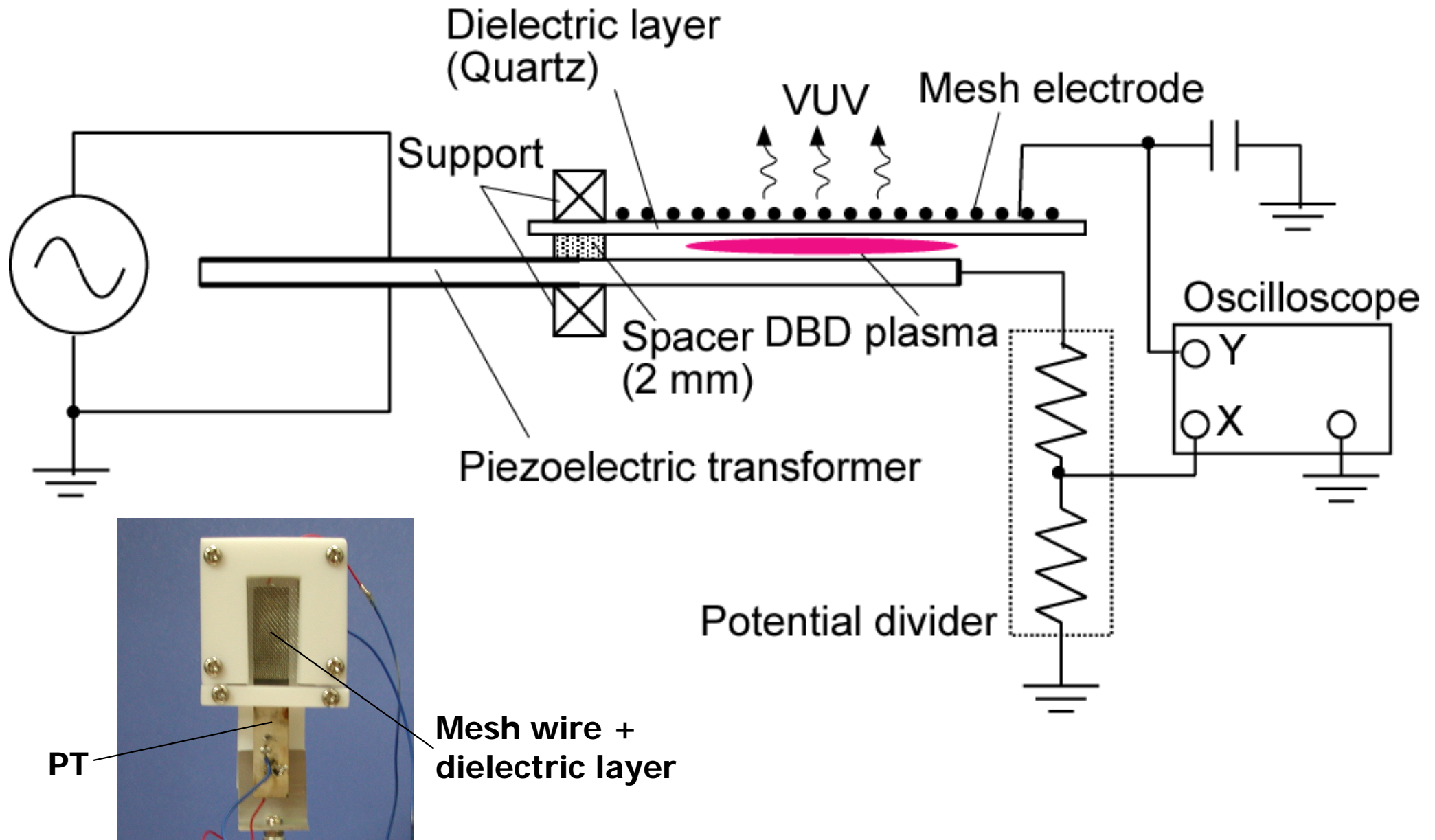
Generable plasmas



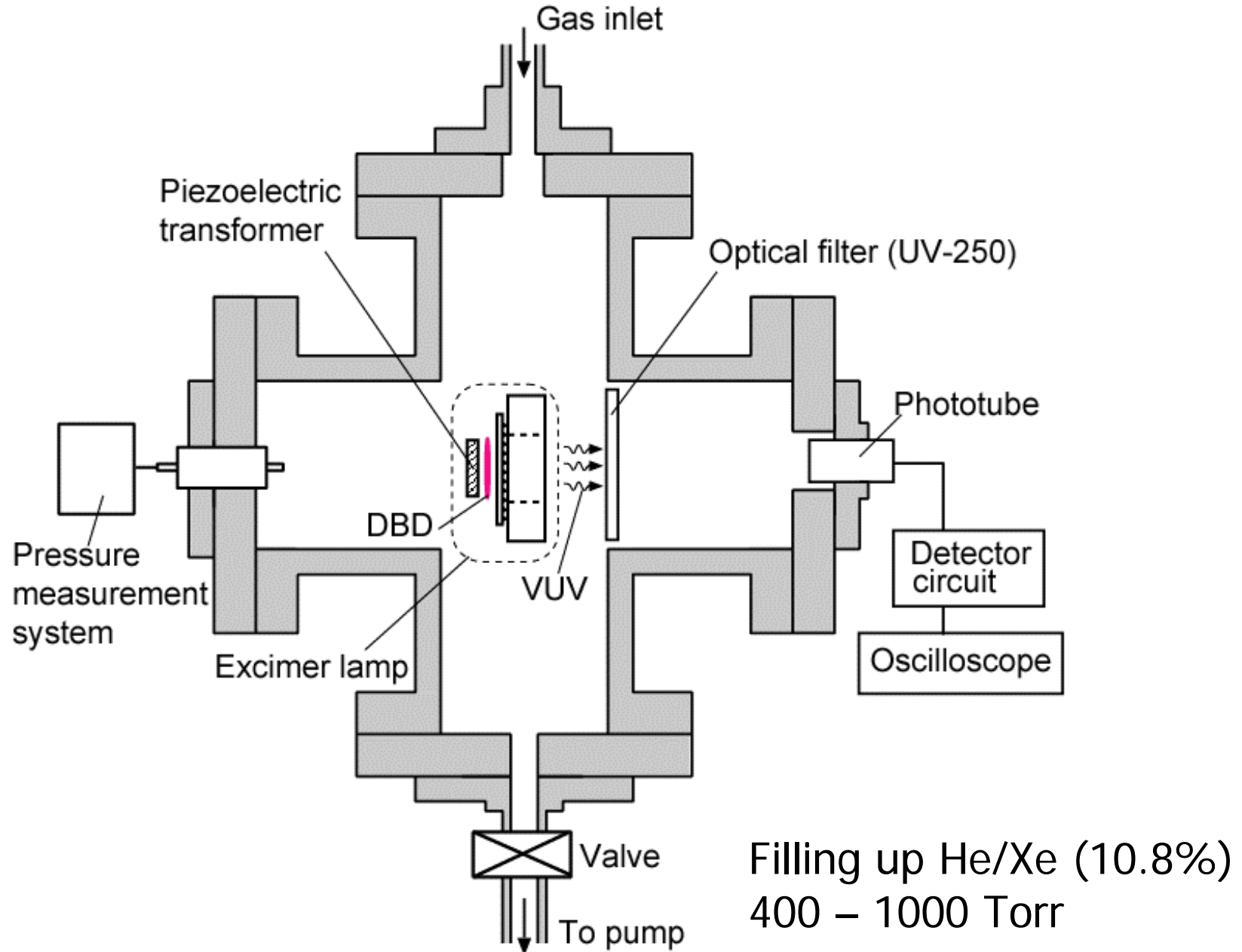
# Principle of the transformer



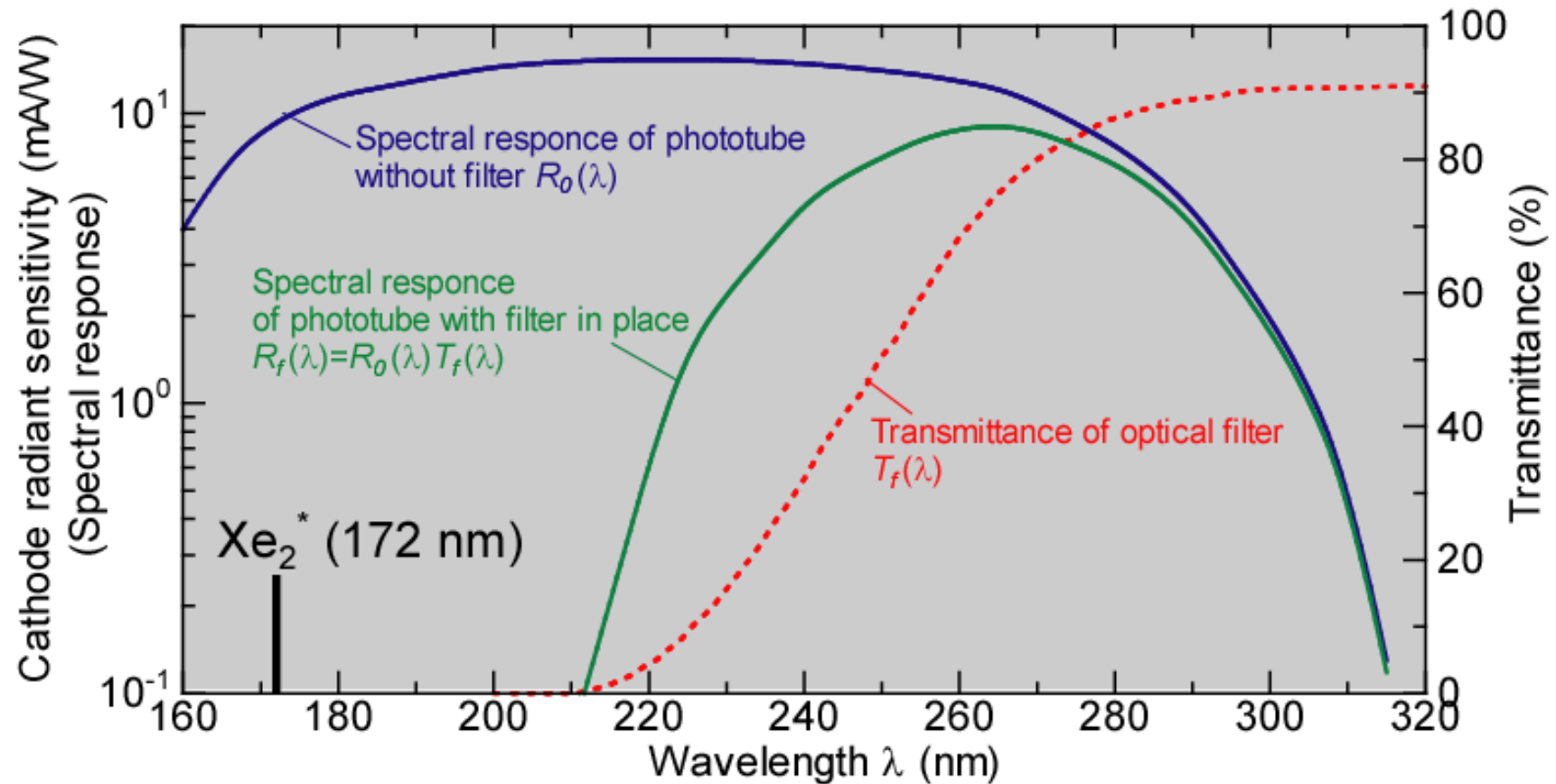
# Configuration of PT-based excimer lamp



# Discharge chamber



# Method of VUV detection



Spectral response of phototube: 160-320 nm

Cutoff wavelength of optical filter (UV-250): 200 nm

Measurements:

Light intensities with/without filter in place,  $S_f$  and  $S_0$

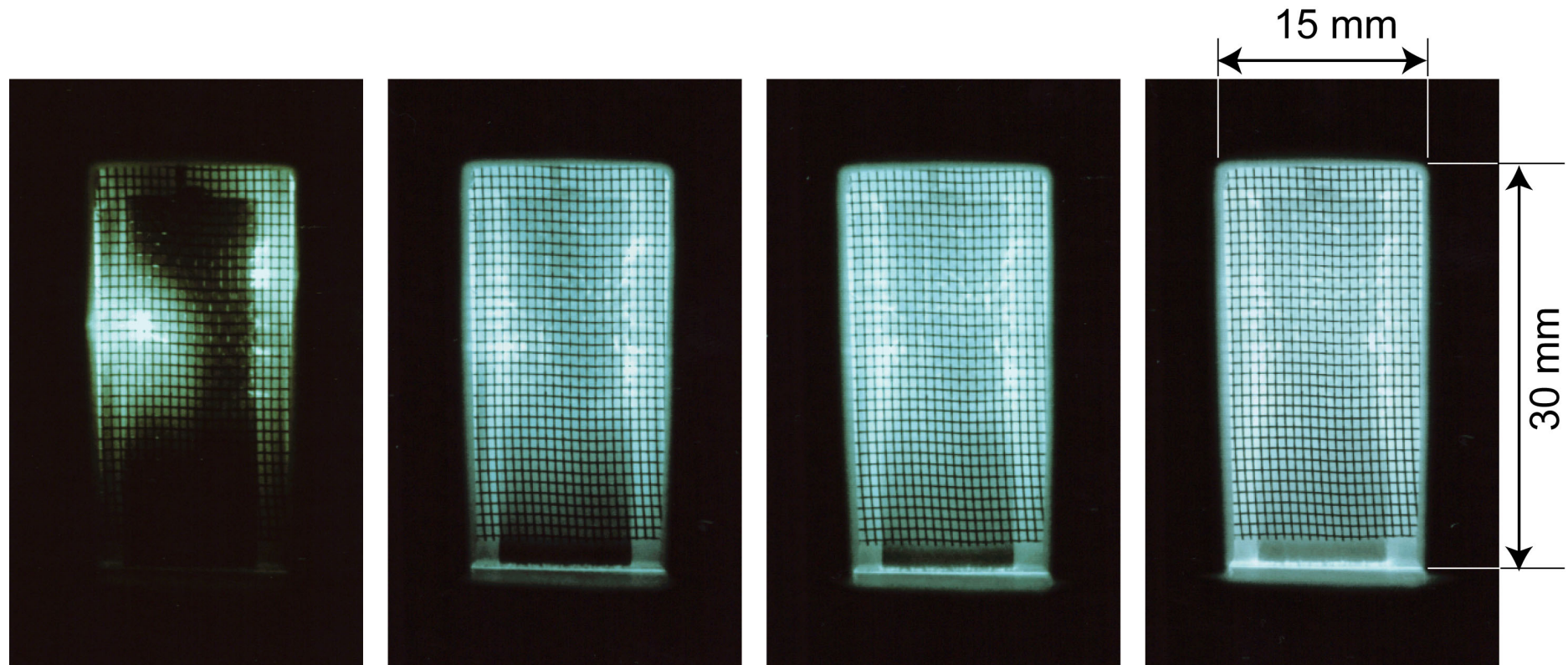


**If VUV (160-200 nm) is radiated from lamp,  $S_f \ll S_0$ .**





# Visible light emissions of excimer lamp



(a)  $V_p=20$  V  
(0.15 W)

(b)  $V_p=30$  V  
(0.35 W)

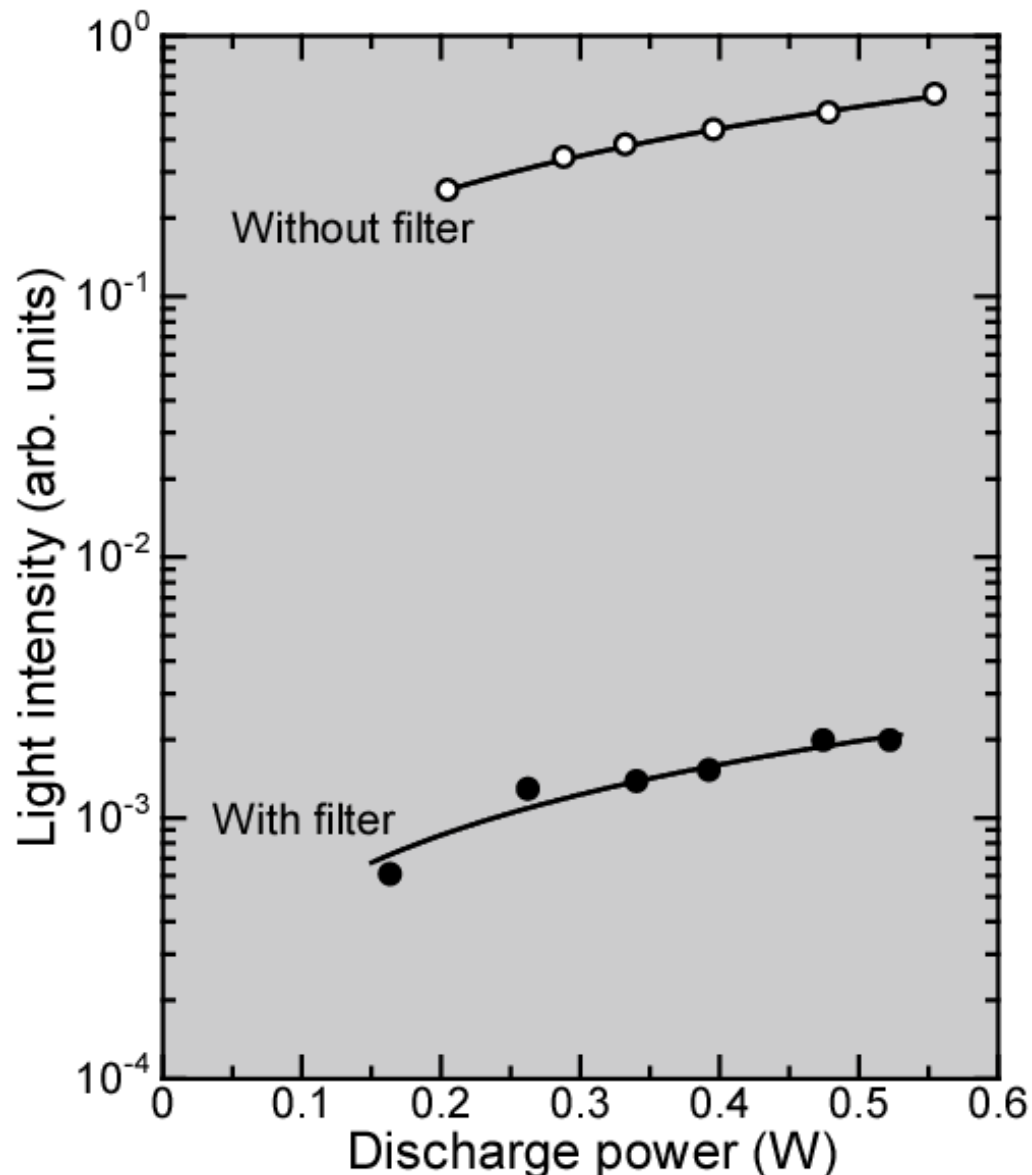
(c)  $V_p=35$  V  
(0.41 W)

(d)  $V_p=45$  V  
(0.55 W)

PT-based Excimer lamp:

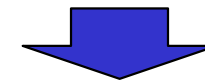
- Operation with **low applied voltages**.
- **Surface light source** with the applied voltage of 45 V.

# Results of VUV detection

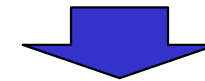


Light intensities  $S_f$  and  $S_0$  are in proportion to the discharge power

**$S_f$  is 4000 times as small as  $S_0$ .  
(99.6% in absorption)**



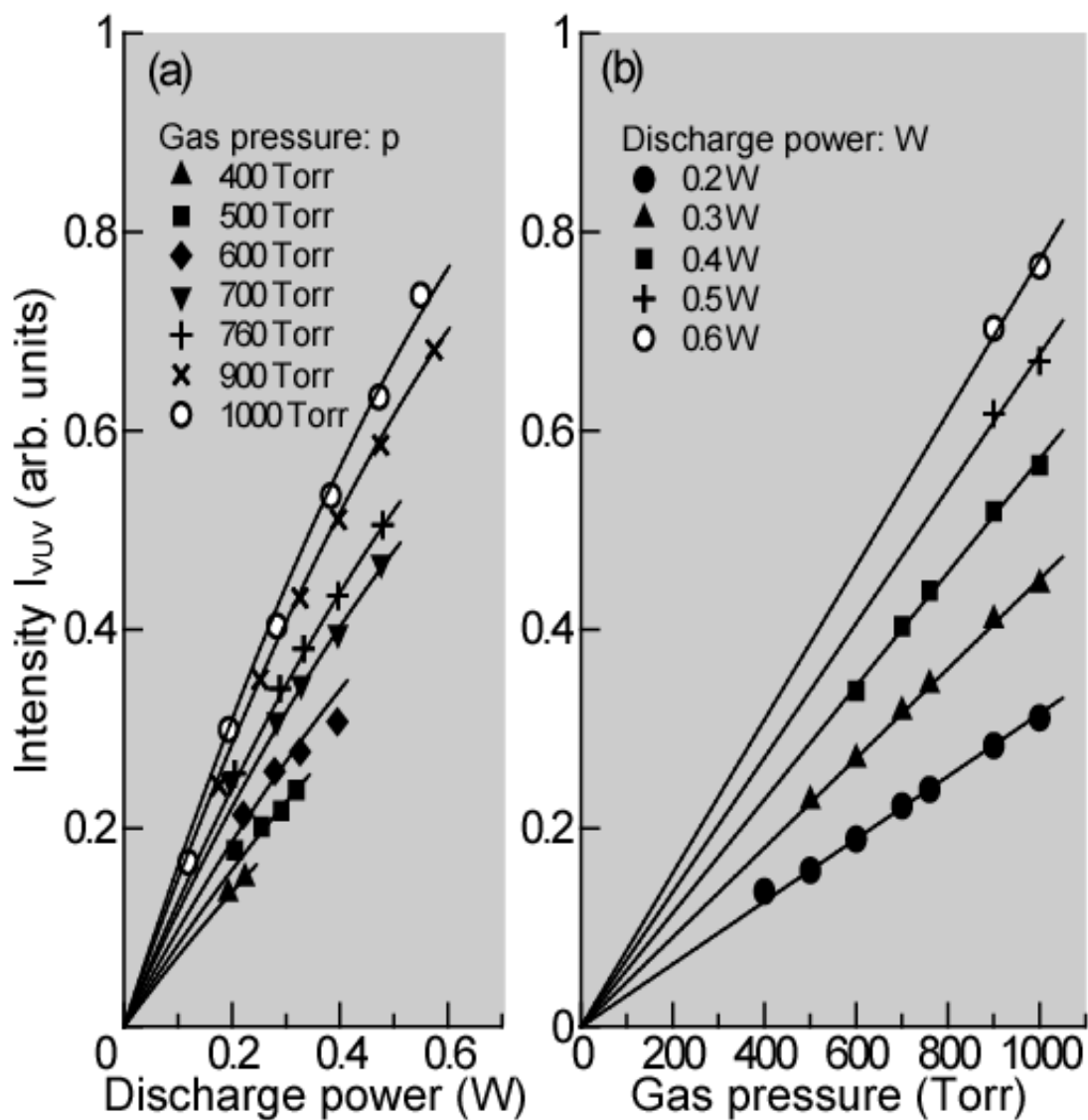
Presence of VUV radiation  
between 160-200 nm



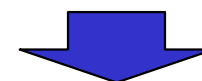
**172-nm VUV due to  $\text{Xe}_2^*$  excimers**  
generated in He/Xe DBD



# VUV Intensity for different gas pressure

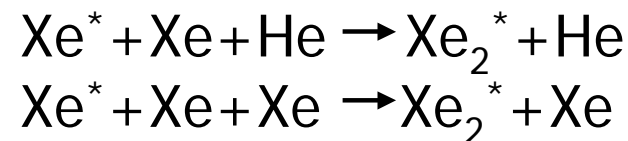


Light intensities are in proportion to the gas pressure.



Concentrations of  $\text{Xe}_2^*$  generated by DBD are proportional to the gas density.

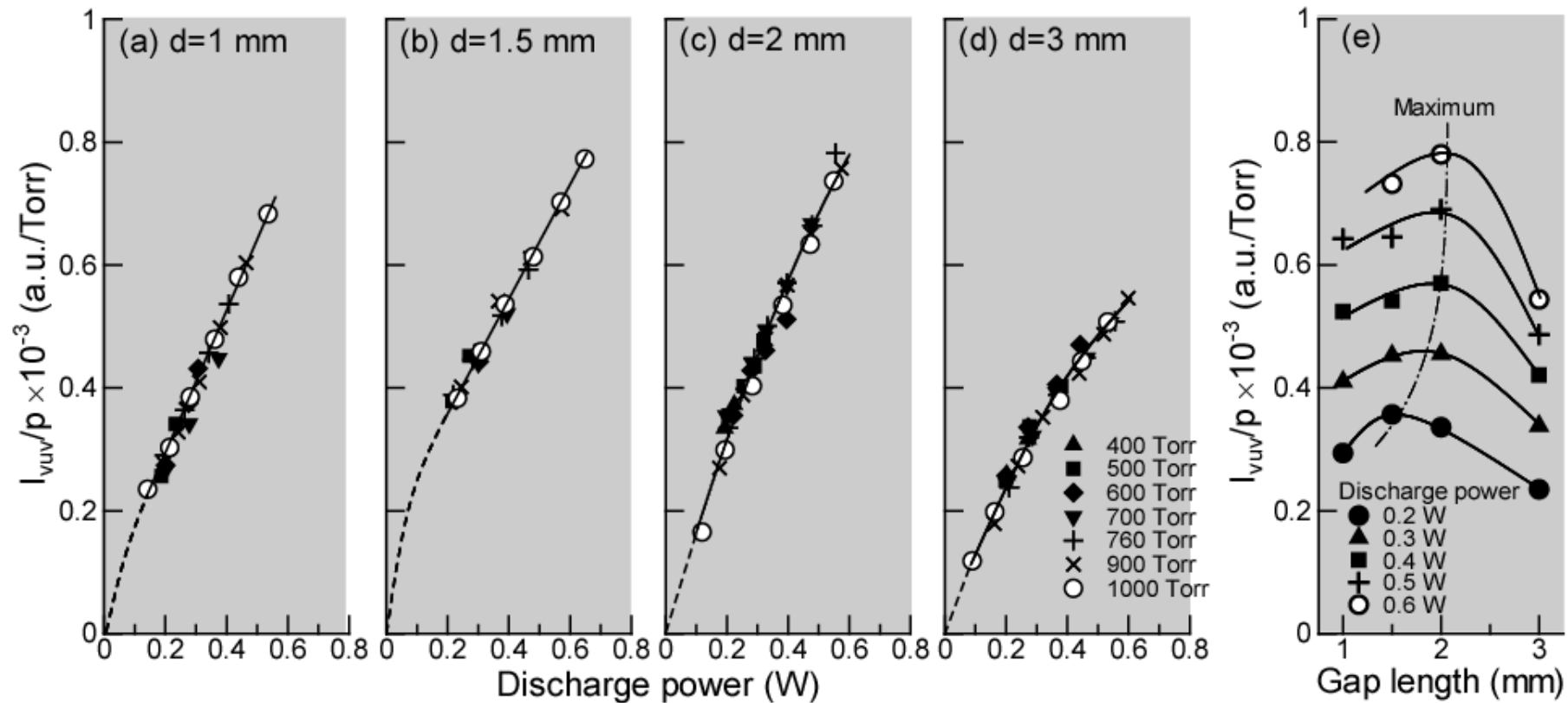
Three-body excimer reactions:



rapidly take place before the decay process of  $\text{Xe}^*$  atoms.



# VUV intensity for different gap length



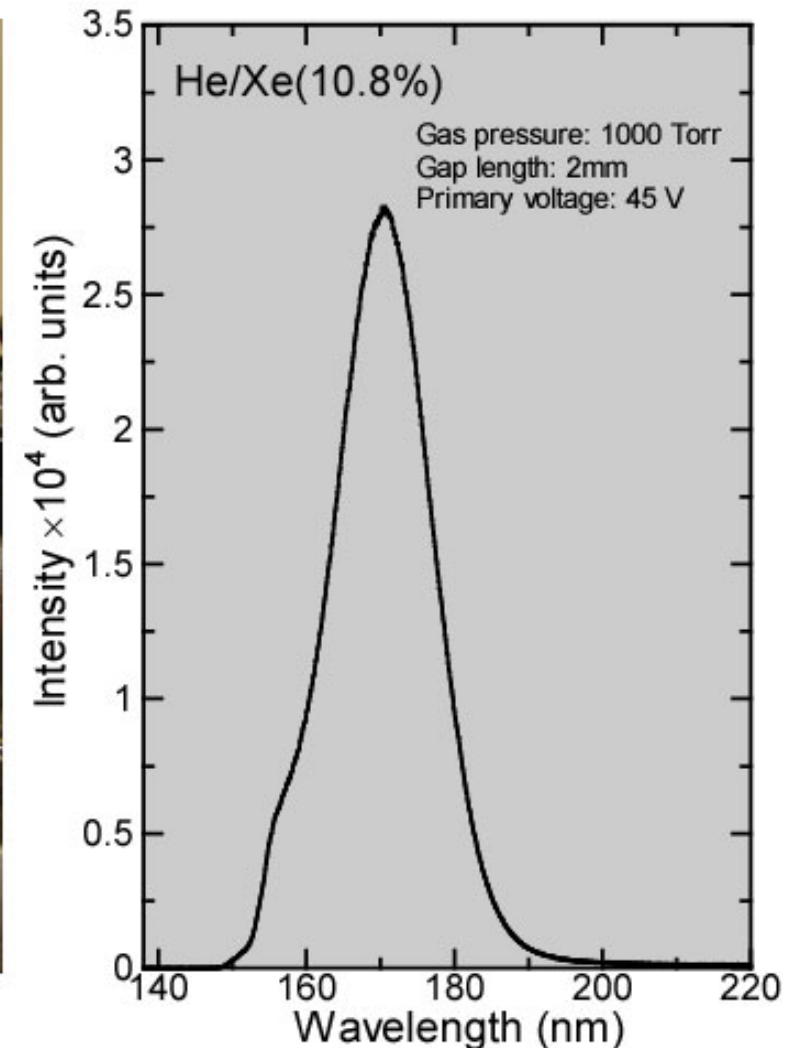
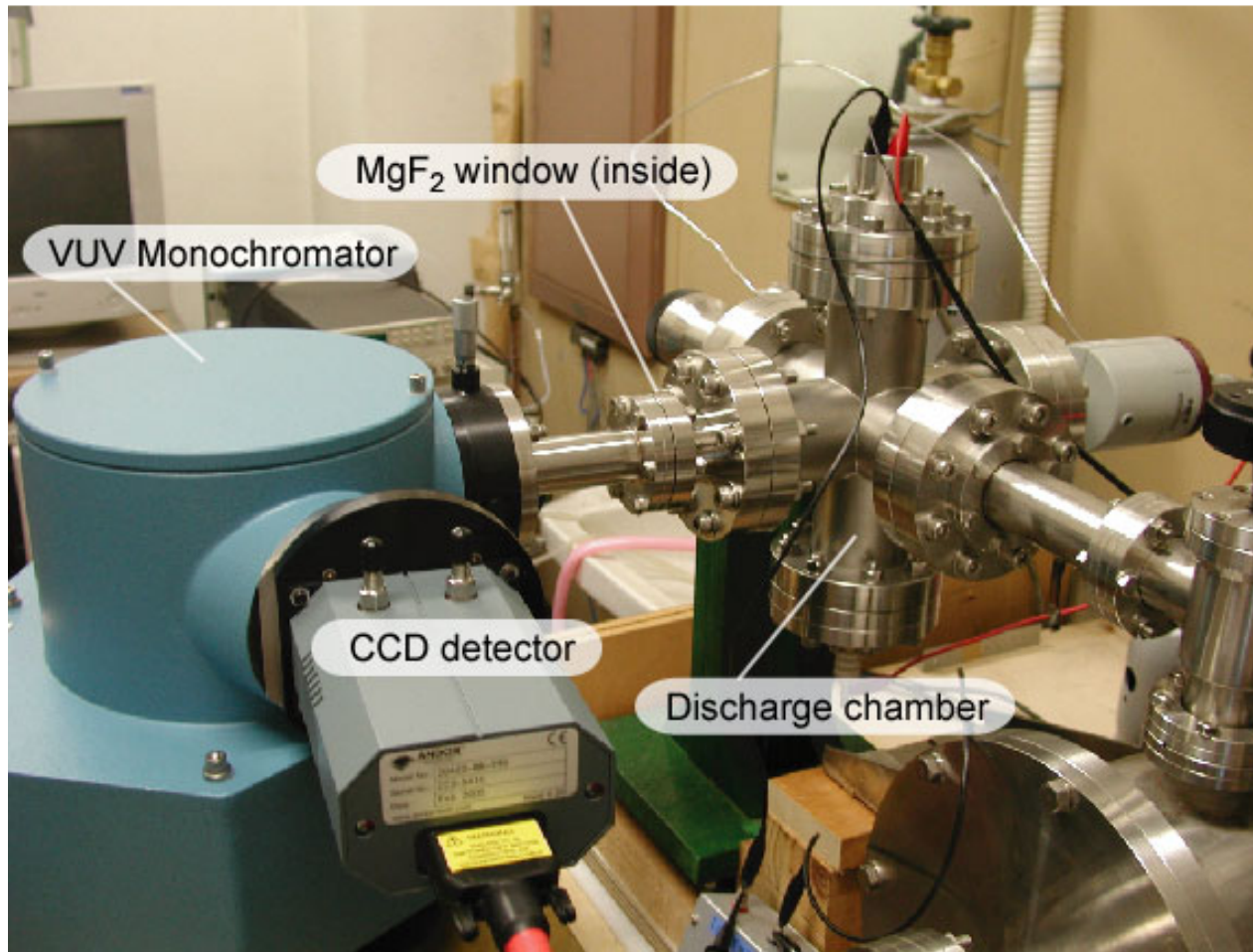
- The vertical axes: the VUV intensities reduced 1 Torr  $I_{\text{VUV}}/p$
- $I_{\text{VUV}}/p$  are proportional to discharge power and independent of gas pressure.

## Optimal performance:

Gap length: 2mm at discharge power between 0.3 and 0.6 W



# Spectroscopic investigation



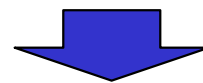
Peak wavelength: 172 nm ( $\text{Xe}_2^*$  excimer)

FWHM: 15 nm



# Summary

- A compact excimer lamp has been constructed by a piezoelectric transformer and the VUV radiation has been investigated in a barrier discharge generated in mixture of helium and xenon.
- The excimer lamp can be operated with low-applied voltage between 15 and 45 V. The lamp works as surface light source.
- The VUV radiation could be detected using a phototube together with an optical filter.
- The VUV characteristics were investigated for different gas pressures and gap lengths. The higher VUV intensities are obtained at higher gas pressure conditions.
- The optimal gap length for the excimer lamp was determined to be 2.0 mm with the discharge power between 0.3-0.6 W.
- The xenon excimer radiation of 172 nm can be also confirmed by a spectroscopic measurement.



PT-based excimer lamp => Compact VUV light source



# Acknowledgement

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Thank you for your kind attention.

