Optimization of Pulsed Voltage Waveform for a Barrier Discharge Lamp with an Inner Electrode

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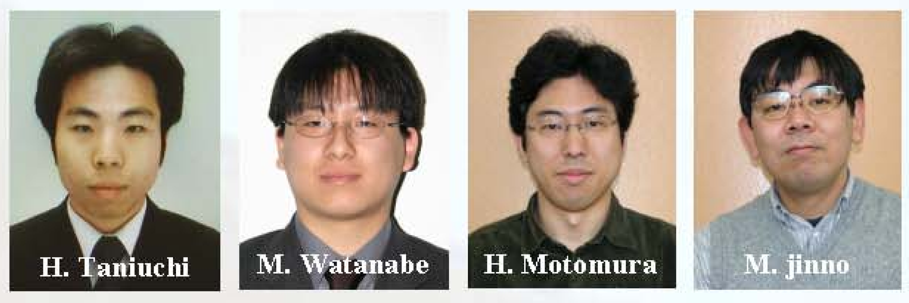


Introduction

Discharge tube using dielectric barrier discharge

↓ ← Applying the pulsed voltage

Discharge occurs in a pulse at the rising and the falling edge o the voltage pulse

↓ → Controlling the pulse width

Influence on the luminance

(Controlling the pulse width ↑ Applying the pulsed voltage)

Timing of the second discharge can be changed by controlling the pulse width

Conclusion

Two radiations → Overlap → Luminance will decrease

Voltage is increased much → A positive column becomes contracted → Luminance will decrease Efficiency will drop

Experiment

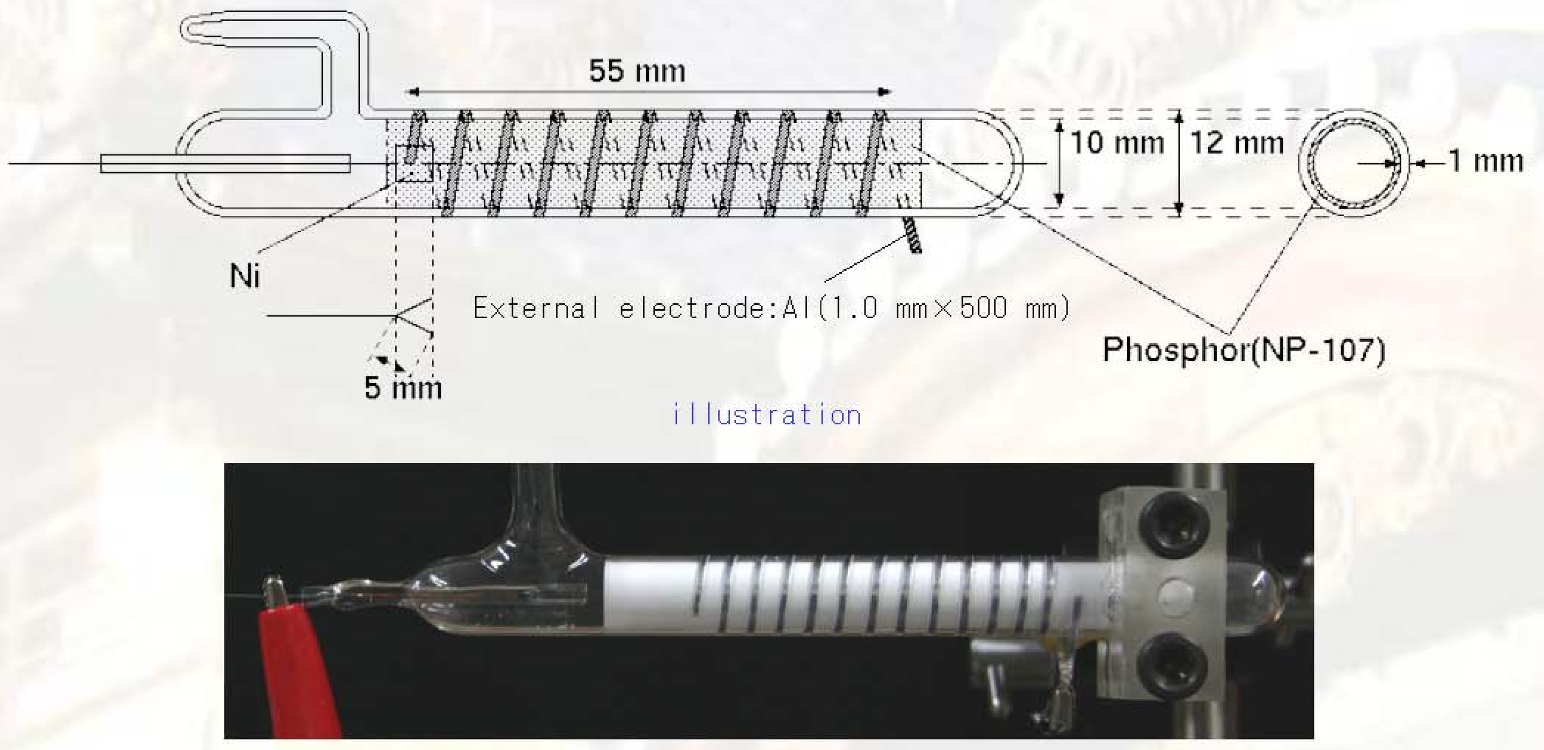


Fig.1. The discharge lamp (The phosphor is applied.)

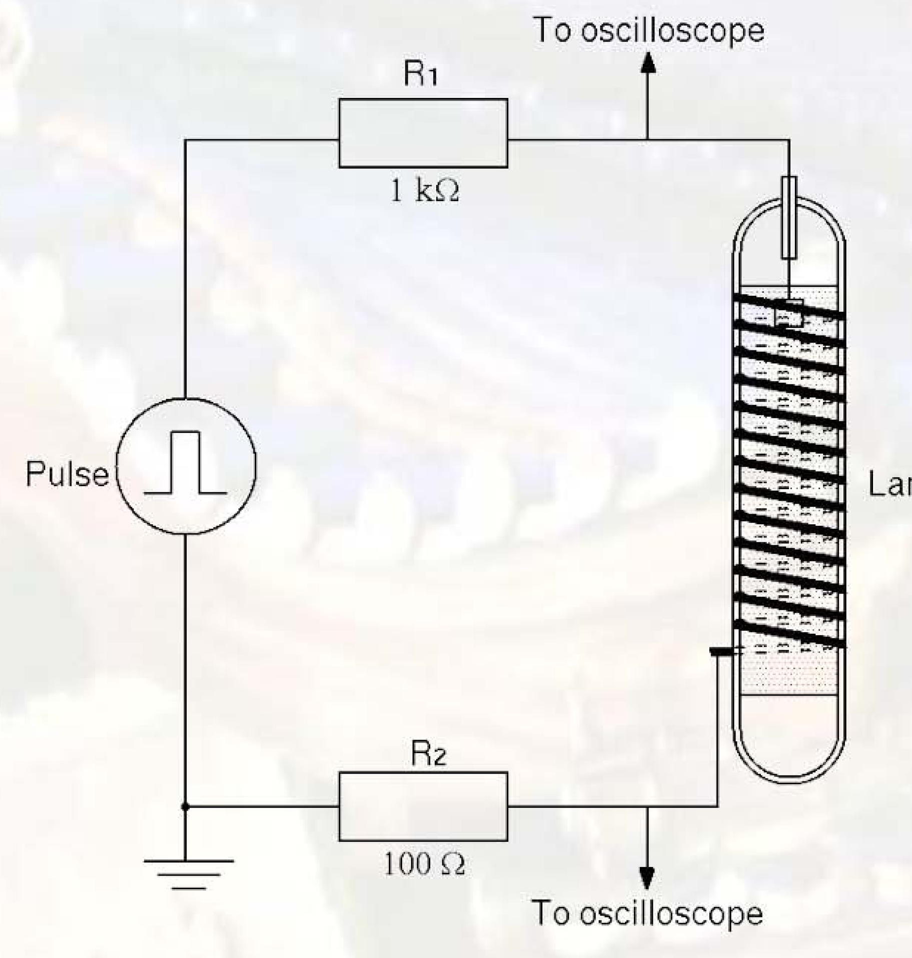


Fig.2. Lighting circuit diagram

Condition

- Waveform of applied voltage : Positive polarity pulse wave
- Pulse width : 2 μs〜98 μs
- Frequency : 10 kHz
- Peak voltage : 1000 V〜3000 V

Measurement

- Luminance at the center of a discharge tube
- Voltage waveform
- Current waveform
- Phosphor radiation waveform at 451 nm

- Filled gas : Xe
- Gas pressure : 6.65 kPa
- Internal electrode : Two nickel plates with 5.0 mm long and connected each other to be "V" form
- External electrode : Aluminum tape of 1.0 mm × 500 mm wound on the outside in helical

Results and discussion

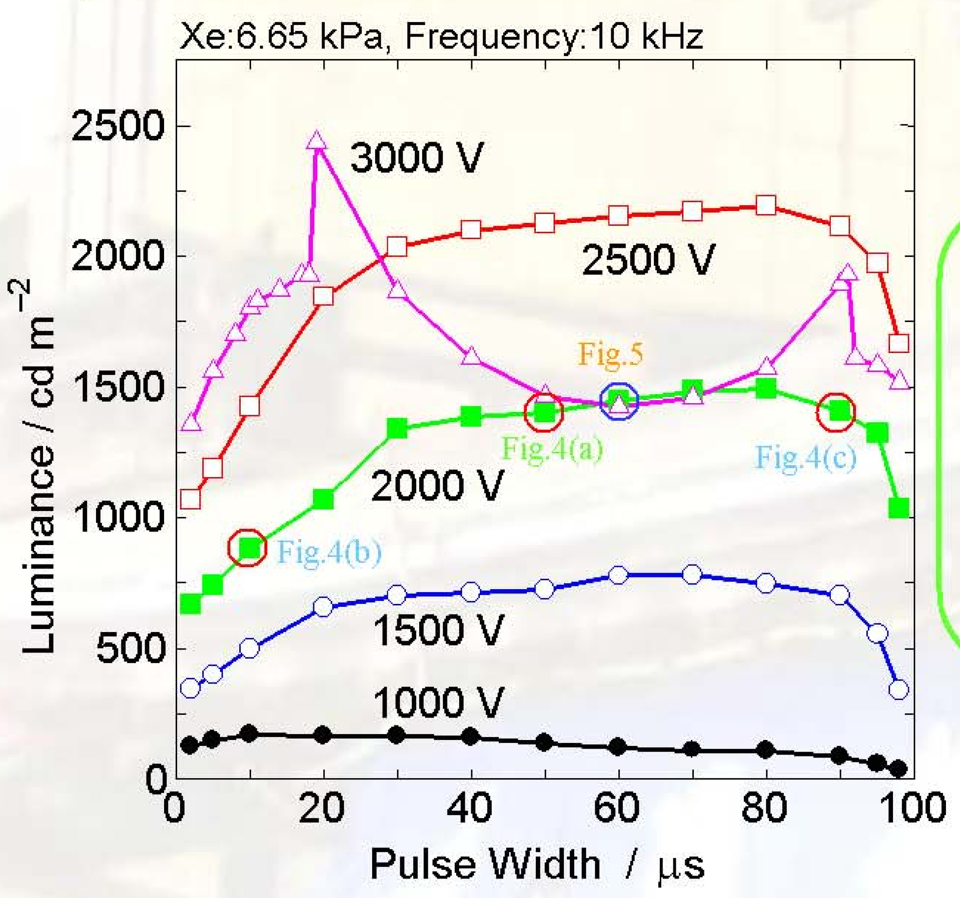


Fig.3. Relation between pulse width and luminance

- Set the pulse width at 30 μs〜about 90 μs

↓

Luminance is high and stable

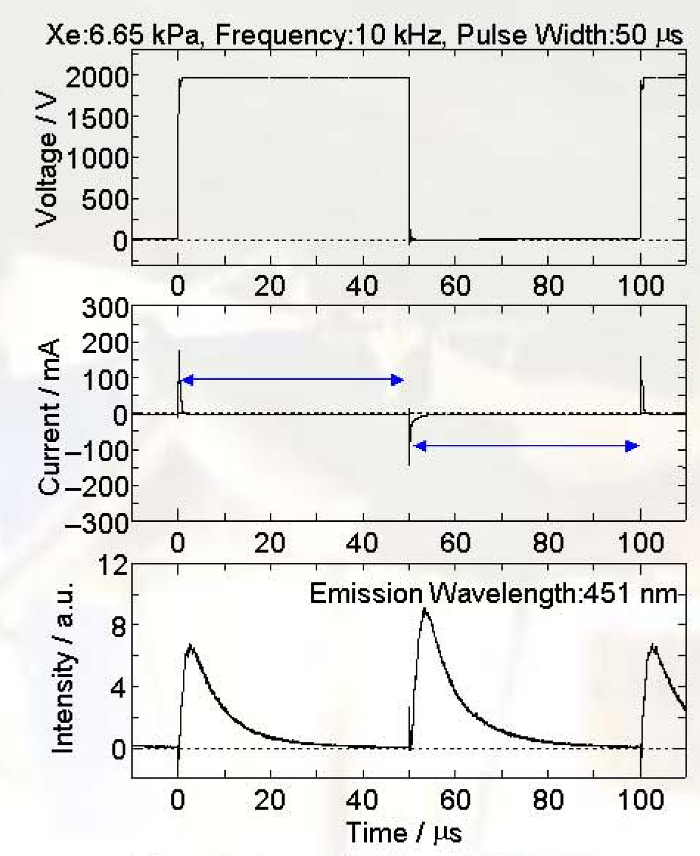
- Pulse width becomes small more than 30 μs
- Pulse width is increased more than about 90 μs

↓

Luminance decreases

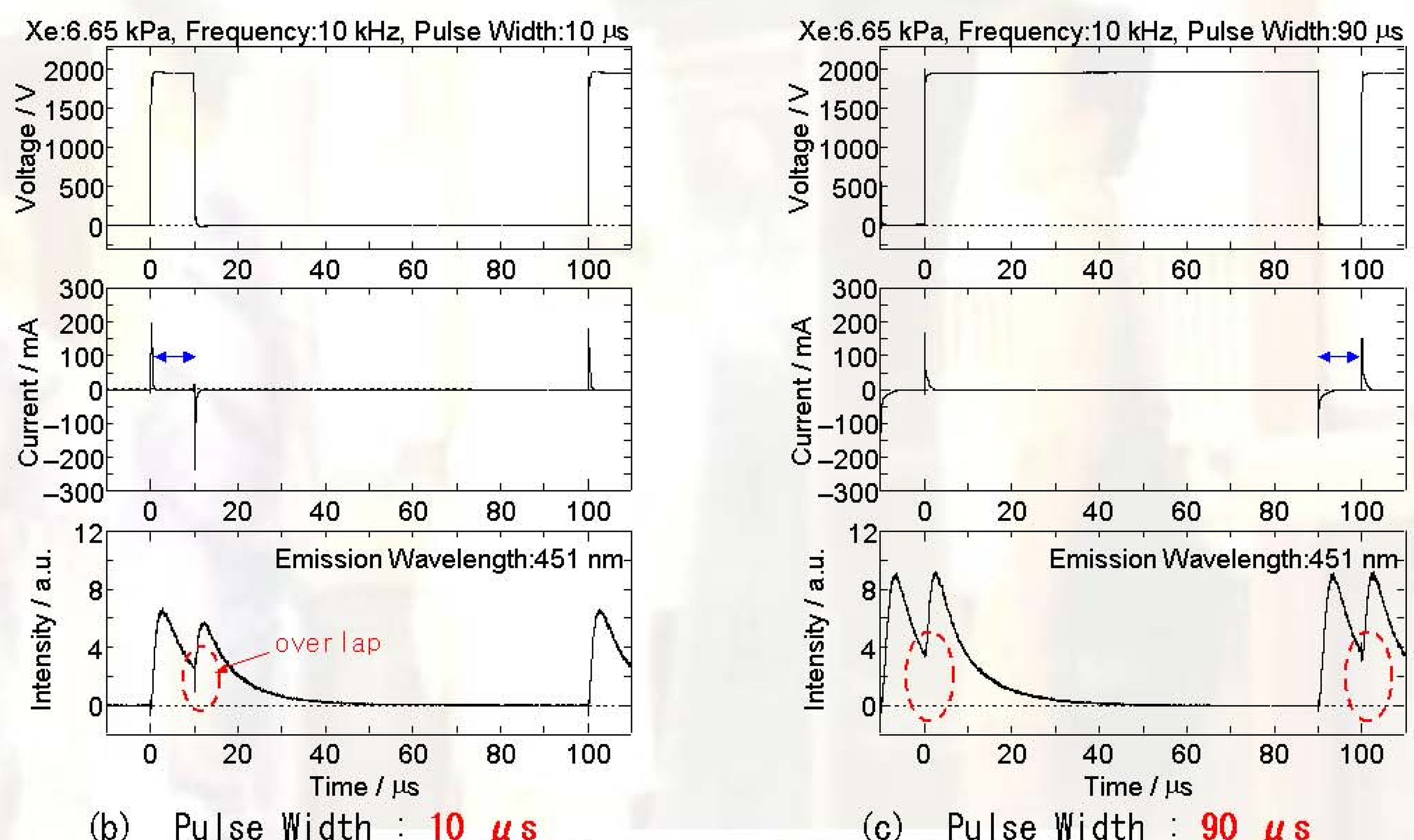
for making luminance high

Set the pulse width at 30 μs 〜 about 90 μs



(a) Pulse Width : 50 μs

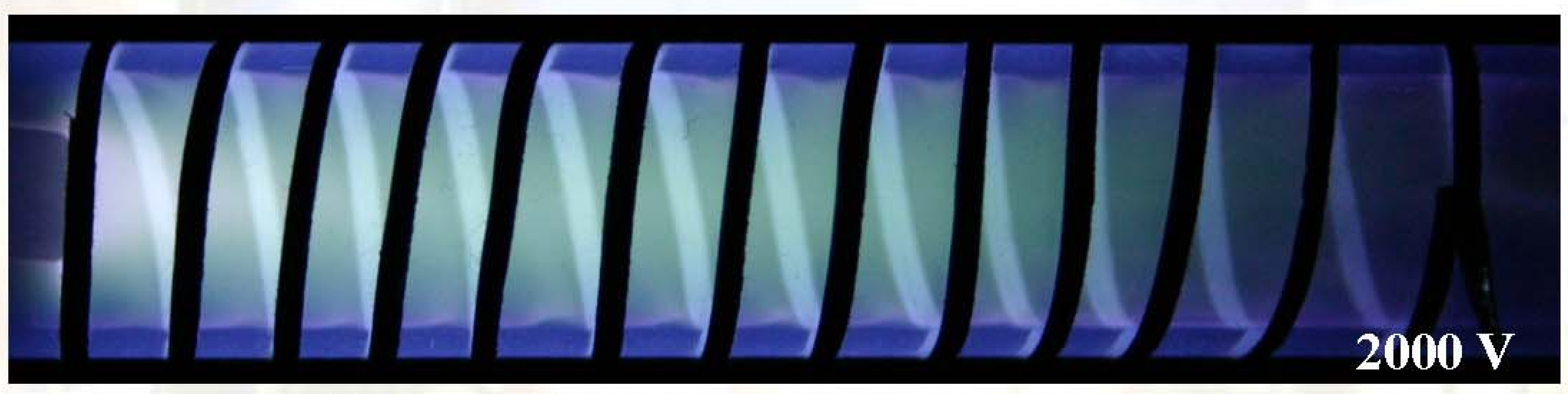
When the discharge interval is long



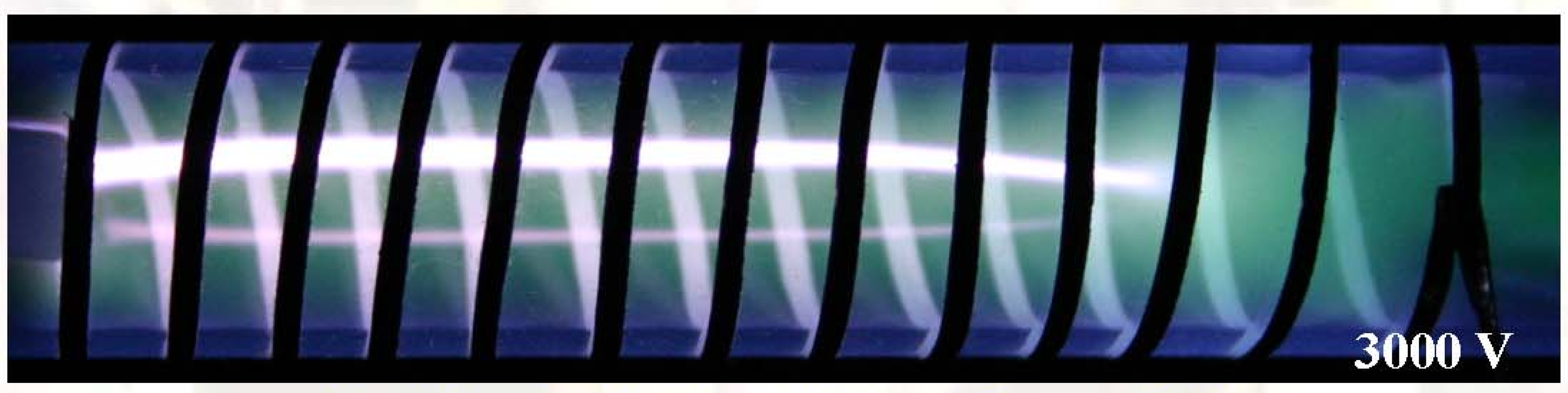
(b) Pulse Width : 10 μs (c) Pulse Width : 90 μs

When the discharge interval is short

Fig.4. The voltage, the current, and the phosphor radiation waveform



Pulse Voltage:2000 V, Pulse Width:60 μs, Frequency:10 kHz



Pulse Voltage:3000 V, Pulse Width:60 μs, Frequency:10 kHz

Fig.5. Appearance of discharge (The phosphor is not applied.)

2000 V ⇒ 3000 V

↓

Positive column is contracted

↓

Luminance decreases efficiency drops

- Ultraviolet radiation of the xenon decreases
- In contracted state since much larger current flows compared with the case of diffuse state, electric power consumption becomes large and efficiency also drops

Discharge interval‥‥‥interval between rising edge and falling edge of the applied voltage

Discharge interval is long ⇒ radiations do not overlap

↓

First discharge ⇒ resonance and metastable atoms are generated

↓

Interval transited to the ground level with VUV emission

↓

Second discharge ⇒ resonance and metastable atoms are generated again

↓

Good efficiency

Discharge interval is short ⇒ radiations overlap

↓

First discharge ⇒ resonance and metastable atoms are generated

↓

Second discharge ⇒ excited to the higher levels or ionized

↓

decrease of the resonance and excimer vacuum ultraviolet radiation that excites the phosphor

↓

Luminance decreases