# Arguments for increased efficiency of a Xe excimer DBD by pulsed instead of sinusoidal excitation

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## Dielectric Barrier Discharge

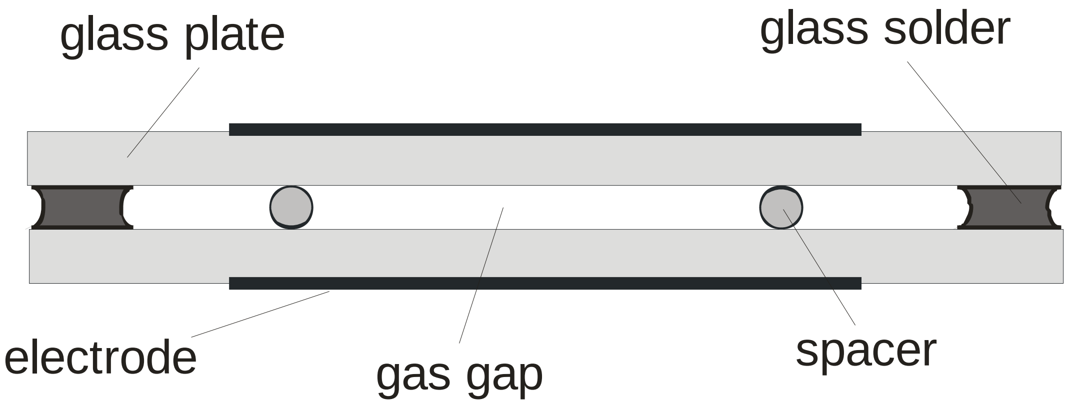
- plane gas discharge
- Xenon excimer
- nonequilibrium plasma
- Efficiency gain due to pulsed instead of sinusoidal excitation [1]
- plasma efficiency up to 65 % [2]

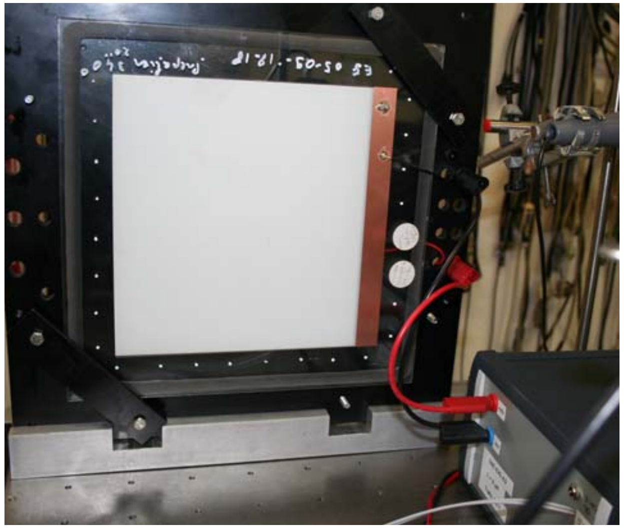
[1] Mildren, Carman, J. Phys. D: Appl. Phys. 34 (2001)
[2] Vollkommer, Hitzschke, US000005604410A (1994)

# Outline

1. Experimental setup
2. Sinusoidal and pulsed excitation
3. Separation of energies
4. Conclusion

## Experimental setup



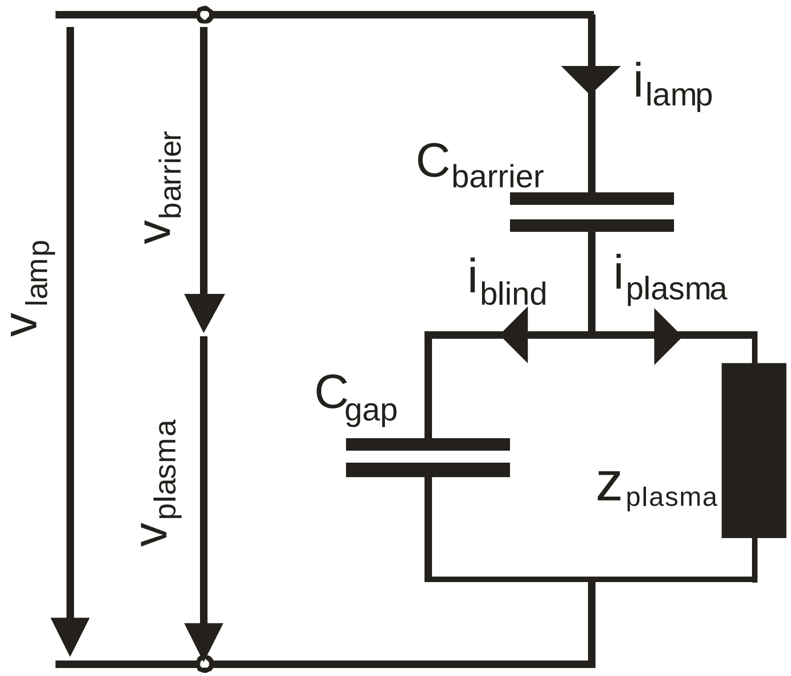



## Measurements:

- lamp luminance L
- time resolved NIR emission (823 nm, 828 nm)
- external and internal electrical values

| | |
|---|---|
| gas gap: | 2 mm |
| xenon: | 125 mbar |
| active area: | 500 cm² |
| frequency: | 40 kHz |
| $V_{lamp(max)}$: | 1.5 - 2.0 kV |

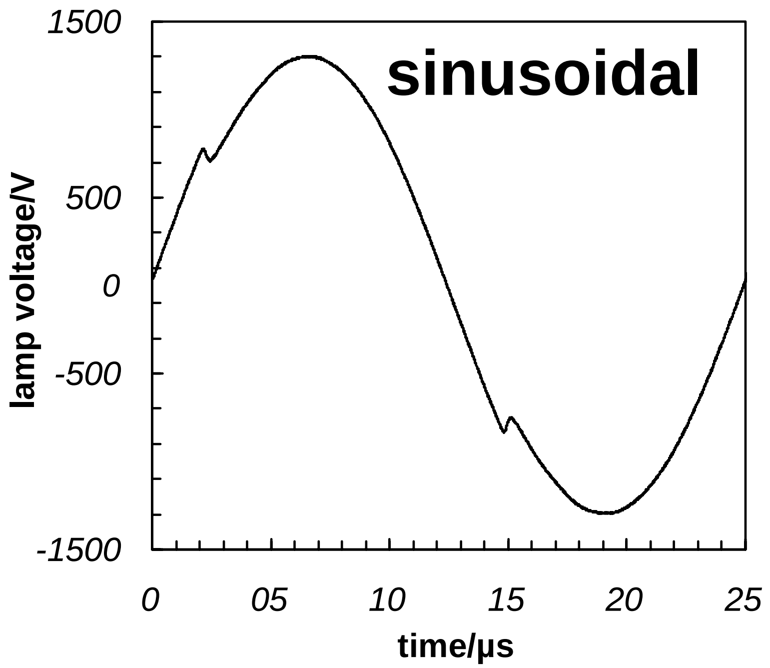
## Internal values

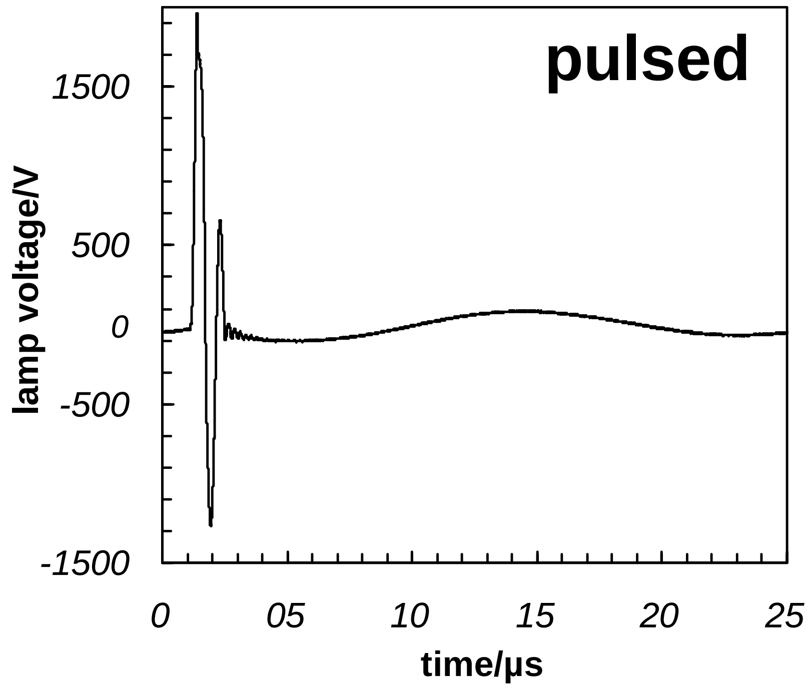



**measurement of internal values:**

- analogue measurement of plasma current
- plasma power without blind component

Roth, M., Neiger, M., 21. IDRC, Nagoya, 2001, p. 893-896

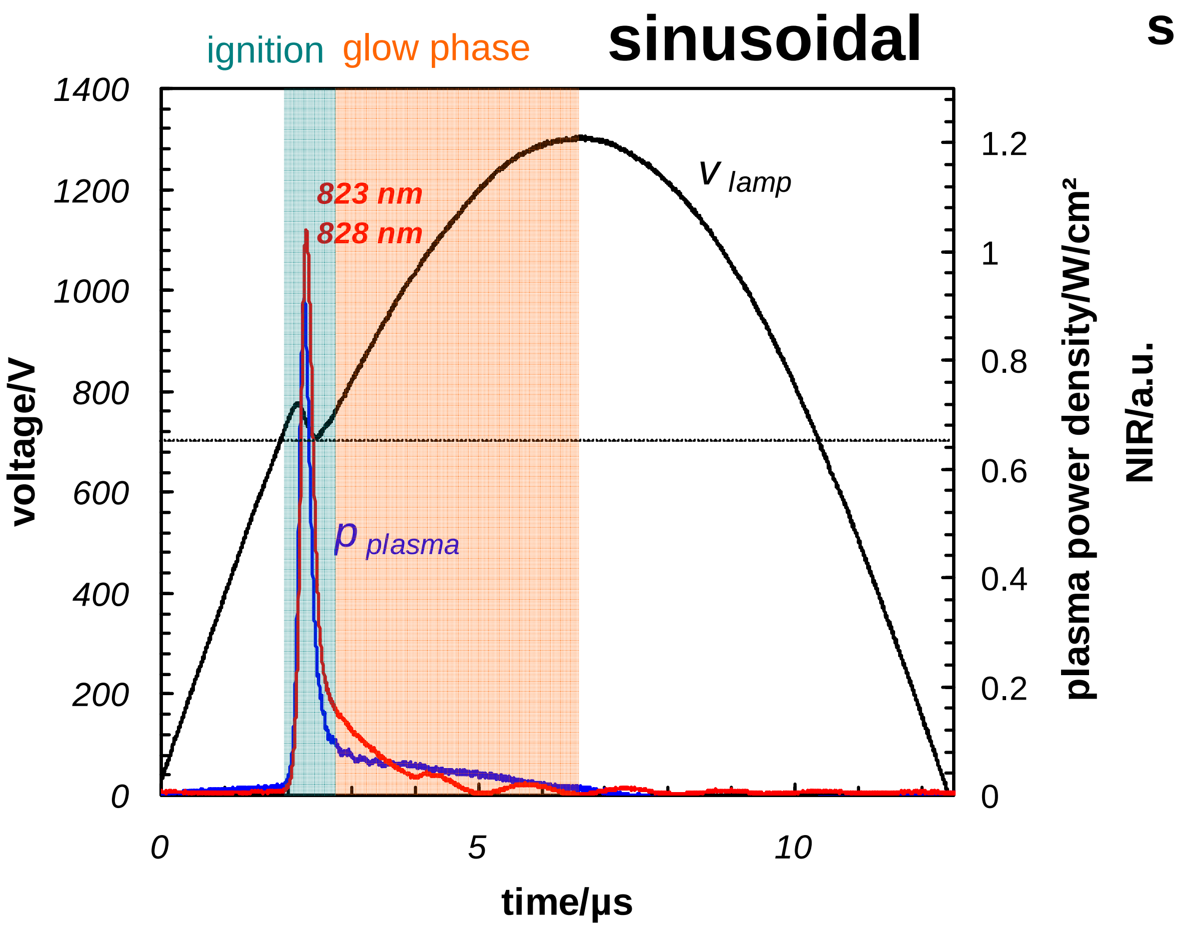



# Electrical excitation

1. sinusoidal ECG
2. resonant pulse ECG with variable pulse length

## Sinusoidal excitation

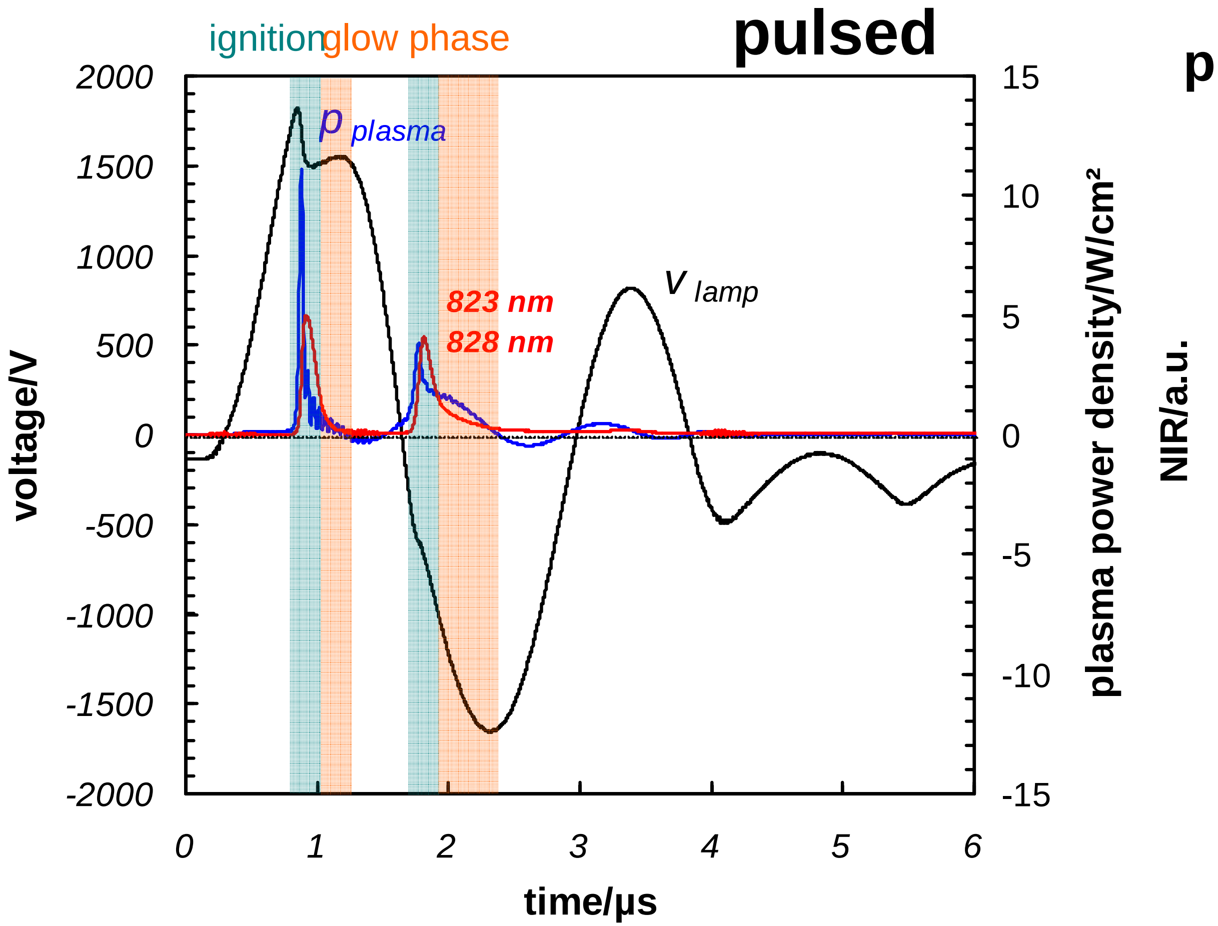



### sinusoidal excitation:

- one ignition per half-wave
- glow phase after ignition
  - power consumption during glow phase
  - filaments still burning

f = 40 kHz, $v_{lamp}$: = 930 Vrms, P = 33 mW/cm², η = 19 lm/W

# Pulsed excitation

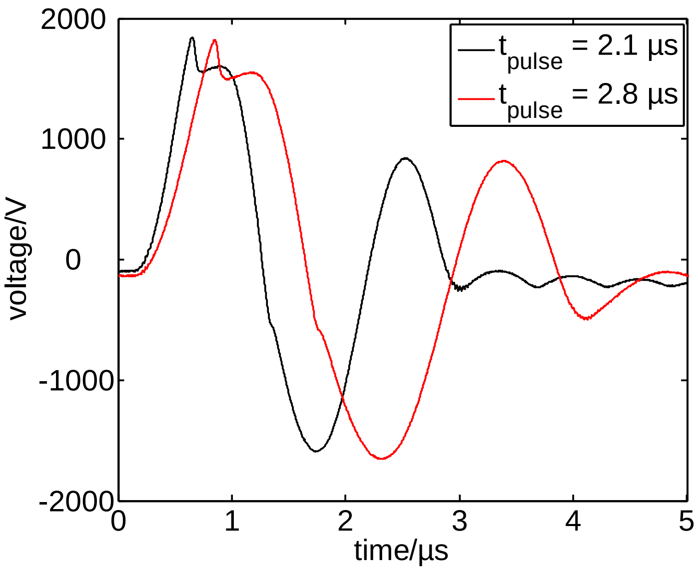


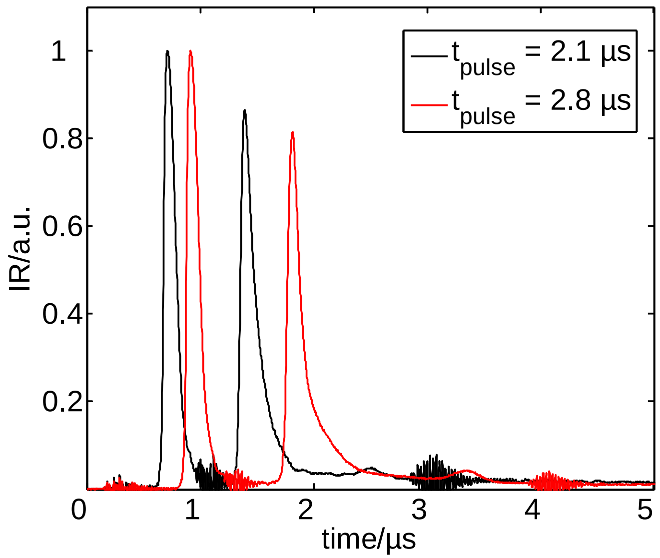

## pulsed excitation

- first and second ignition per pulse
- short glow phase after ignition
  - discharge still burning during glow phase

f = 40 kHz, pulse length 2.8 µs, P = 64 mW/cm², η = 17 lm/W

# Pulsed excitation

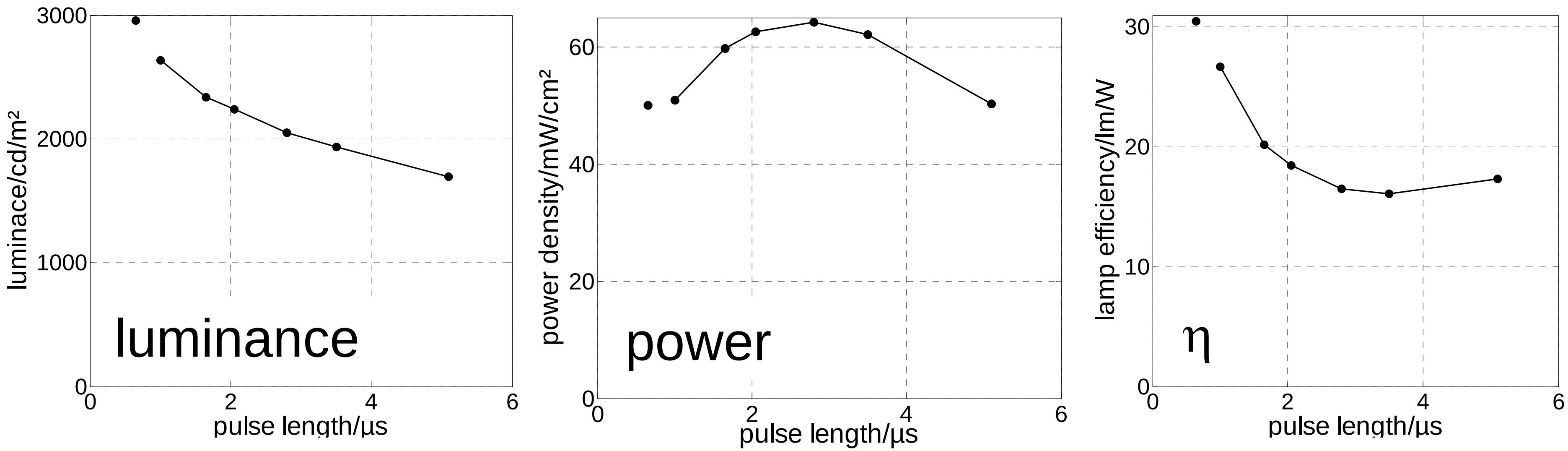



## pulsed excitation

- variation of pulse length
- pulse length 0.6 µs to 5.1 µs
- constant pulse shape
- $V_{lamp(max)}$ = 1.5 - 2.0 kV

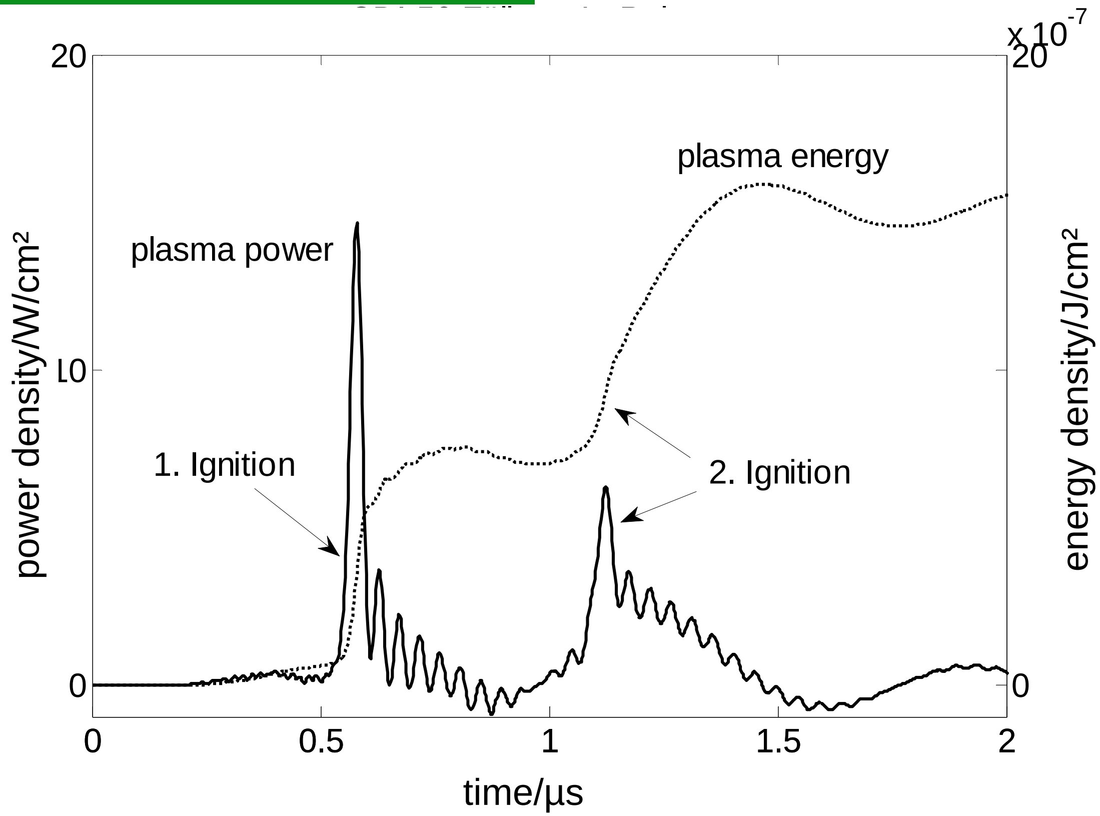
# Pulsed excitation




## pulsed excitation

- luminance up to 3000 cd/m² for $t_{pulse}$ = 0.6µs
- lamp efficiency rising up to 30 lm/W
- power density P = 50 - 62 mW/cm²

# Separation of energies



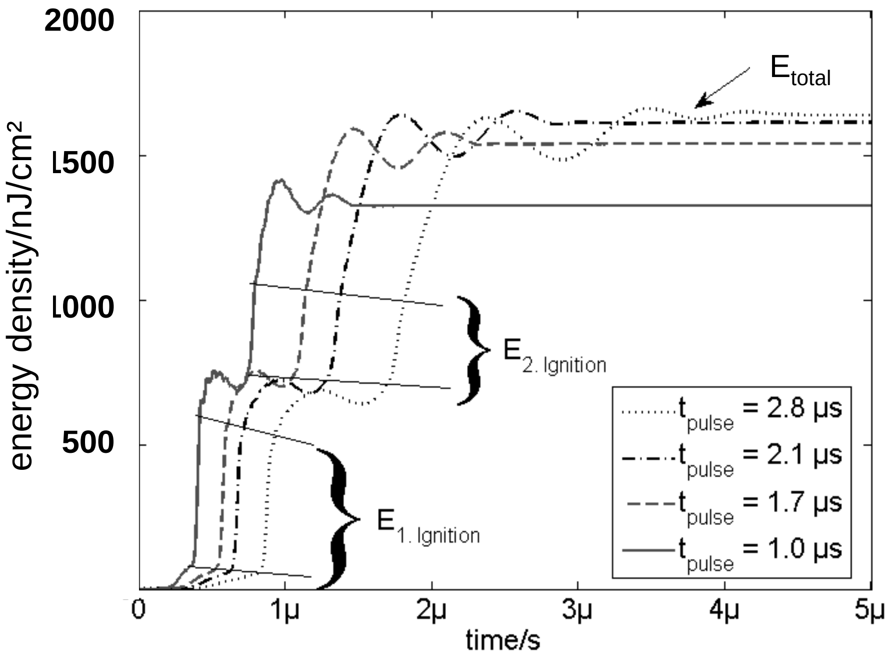

**Ignition phase:**

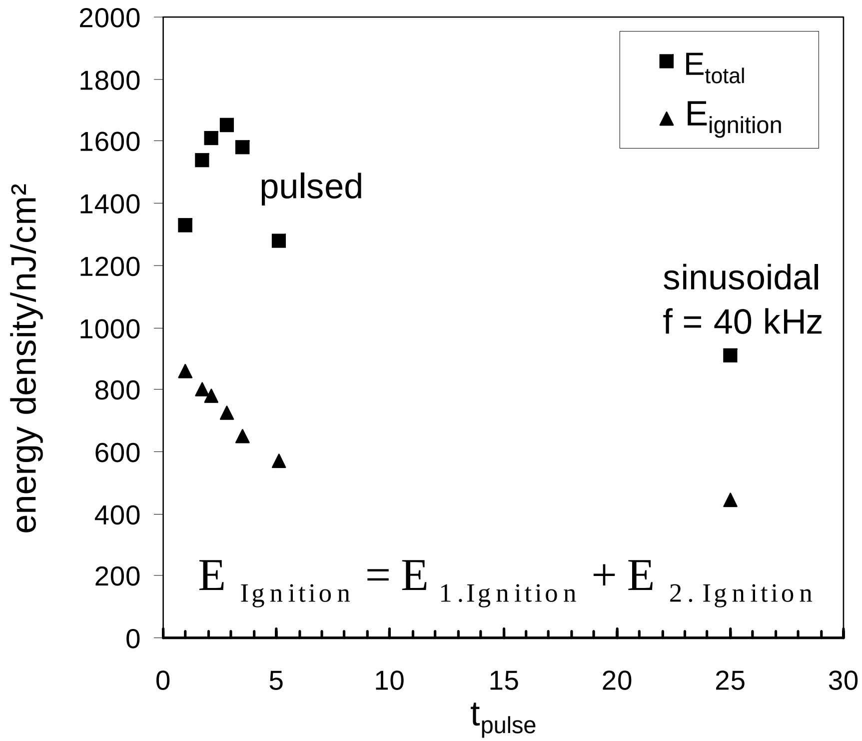
- excitation of Xe* and Xe**
- generation of VUV radiation

**glow phase:**

- $Xe^+$ heating, negligible generation of Xe*, Xe**
- **Simplification: no VUV radiation is generated**

## Separation of energies

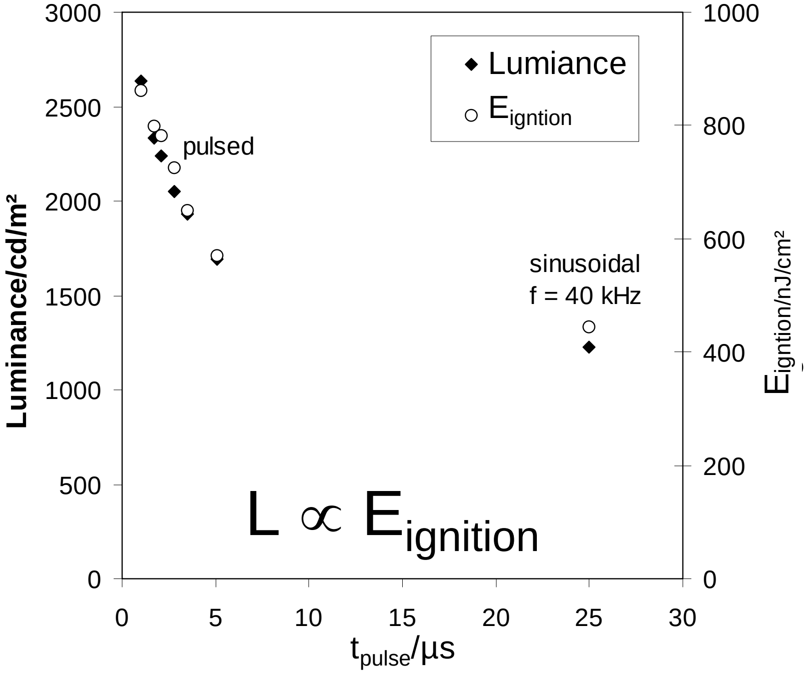


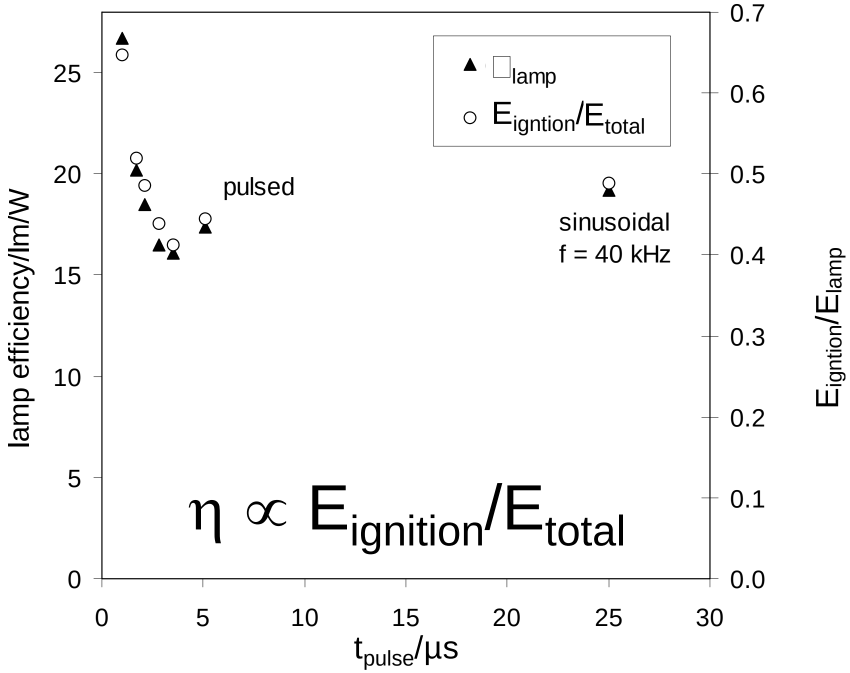




**Separation of energy:**

- ignition energy rises with decreasing $t_{pulse}$
- ratio of ignition energy to total lamp energy depends on pulse length

# Separation of energies




**good correlation between light and ignition energy:**

⇨ high efficient excitation during ignition

⇨ losses during glow phase

**Conclusion:**

⇨ reduce glow phase energy by short pulses

## Summary

- Compared sinusoidal and pulsed excitation
- Separation into ignition and glow phase
- Correlation:

  $L \propto E_{ignition}$

  $\eta \propto E_{ignition}/E_{total}$
- High efficiency due to reduction of glow phase losses

Thank you for your attention.