

The Sulfur Lamp

Lecture:
Inkohärente Lichtquellen
SS2013



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History

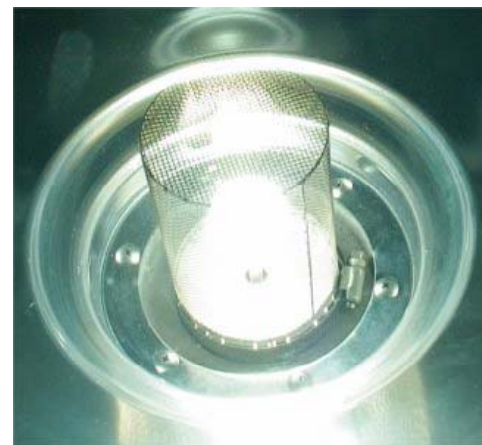
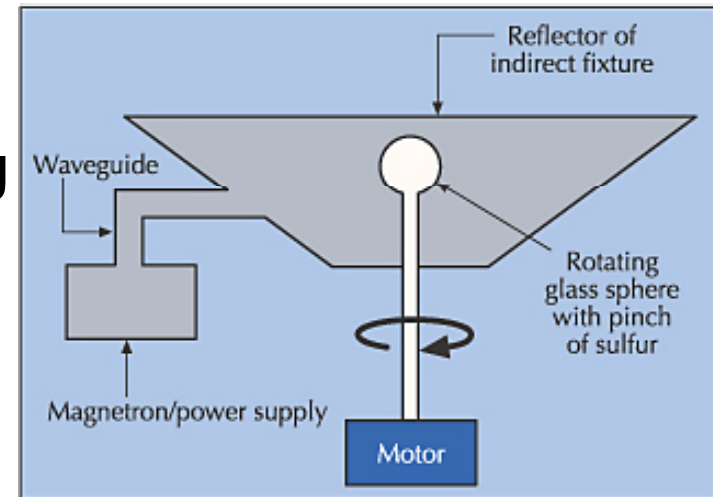
- ▶ **1990: Discovery**
 - by M. Ury and C. Wood (Fusion Systems Corporation)
- ▶ **1994–1997: 2 types of Sulfur Lamps (Solar 1000; Light Drive 1000) by Fusion Lighting**
- ▶ **1998: Production stop; Patents were licensed to LG**
- ▶ **2006: LG → start of production (PLS)**
- ▶ **Today: Research on Sulfur Lamps with electrodes**



Functional Principle

► Construction:

- Fused quartz bulb (30 mm) filled with argon (1 bar) and mg of sulfur powder
- Bulb on a spindle → rotation
- Magnetron: sends out microwaves (@ 2,45 GHz)
- Parabolic reflector





Functional Principle

- ▶ Microwave induction lamp (without electrodes)
 - ▶ Microwaves excite the argon → 5 bar pressure
 - ▶ Plasma of sulfur → many excited states (molecular emission)
- ⇒ Many lines in the spectra

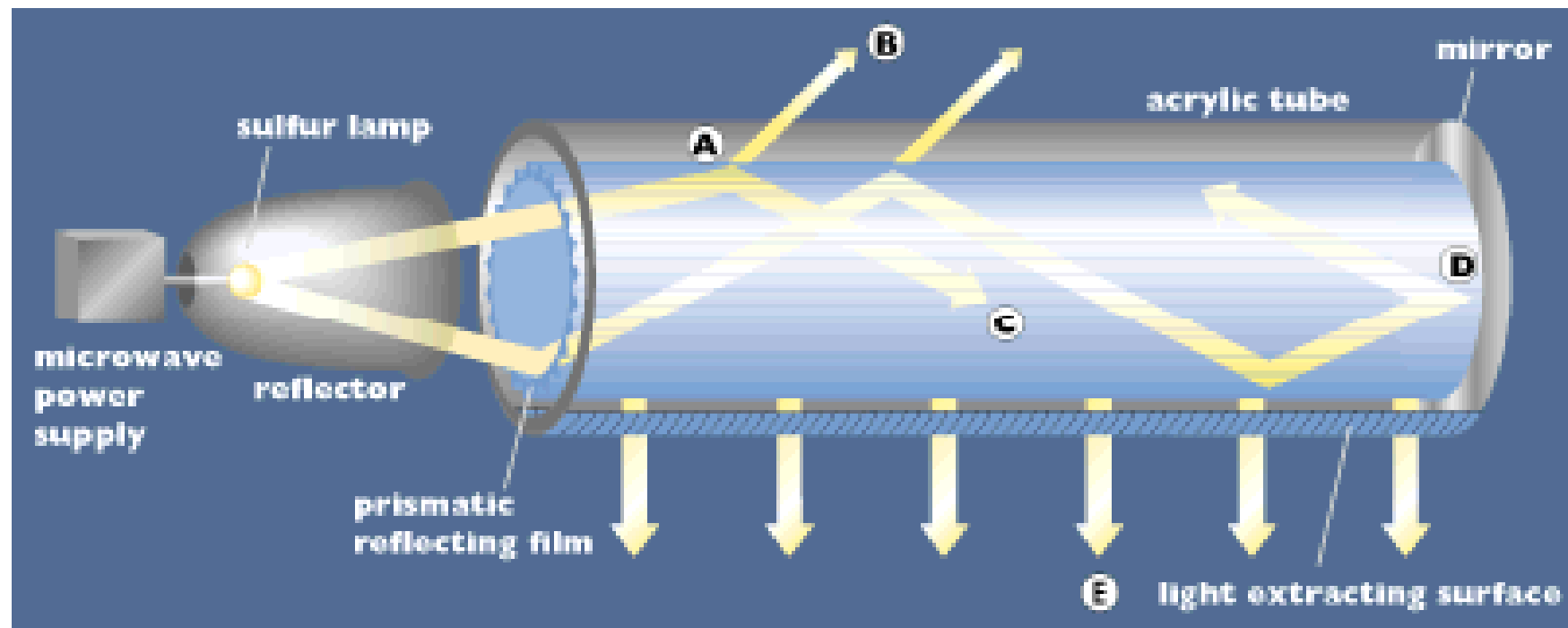
| Reaction | | Energy [eV] |
|----------|--------------------------------|-------------|
| S_3 | $\rightleftharpoons S_3^+ + e$ | 10.6 |
| S_3^- | $\rightleftharpoons S_3 + e$ | 2.1 |
| S_3 | $\rightleftharpoons S_2 + S$ | 0.8 |
| S_2 | $\rightleftharpoons S_2^+ + e$ | 9.36 |
| S_2^- | $\rightleftharpoons S_2 + e$ | 1.67 |
| S_2 | $\rightleftharpoons S + S$ | 4.46 |
| S | $\rightleftharpoons S^+ + e$ | 10.36 |
| S^- | $\rightleftharpoons S + e$ | 2.1 |

| Reactants | | Products | ΔE [eV] |
|-----------|-------------------|-----------------|-----------------|
| $S_2 + X$ | \leftrightarrow | $2S + X$ | 4.46 |
| $S_2 + e$ | \leftrightarrow | $S_2^+ + e + e$ | 9.36 |
| S_2^- | \leftrightarrow | $S_2 + e$ | 1.8 |
| $S + e$ | \leftrightarrow | $S^+ + e + e$ | 10.4 |
| S^- | \leftrightarrow | $S + e$ | 2.0 |
| $Ar + e$ | \leftrightarrow | $Ar^+ + e + e$ | 15.76 |



Functional Principle

- ▶ How to use and distribute the light?
→ Light pipes





Properties

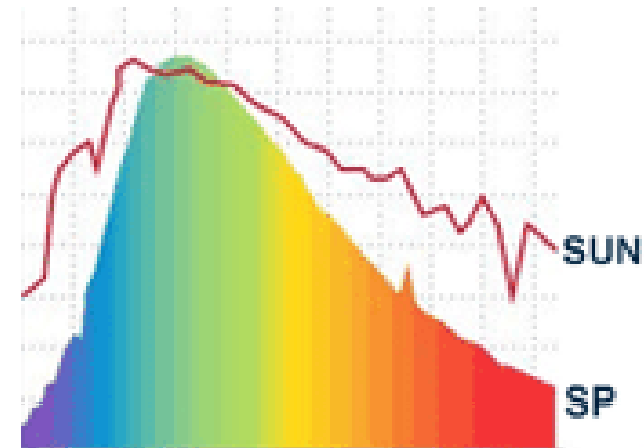
Typical Parameter:

- ▶ Power: 1.400 W
- ▶ Diameter of the bulb: ca. 30 mm
- ▶ Luminous flux: 135.000 Lumen
- ▶ Offset time: 25 s
- ▶ Lifetime (Illuminant): 60.000 h
- ▶ Lifetime (Magnetron): **20.000 h**
- ▶ Luminous efficiency: 95 lm/W



Properties

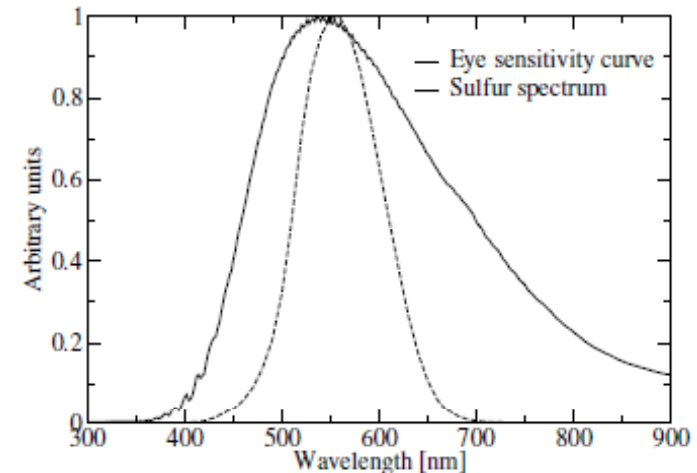
- ▶ Color temperature:
~6.000 K
- ▶ Nearly solar spectra
- ▶ Low emission in UV and IR
- ▶ Dimmable
- ▶ Relatively long lifetime
- ▶ Does not harm the environment
- ▶ Reduce the required amount of energy





Properties

- ▶ Maximum at 536 nm (eye sensitive curve) → greenish (adjustment due to use of other materials or color filter)
- ▶ High voltages are required
- ▶ Short lifetime of the magnetron
- ▶ Magnetron consumes the most energy
- ▶ Need of rotation and cooling



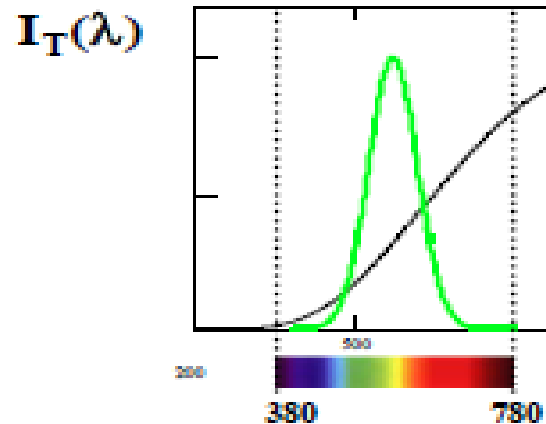


Comparison to other Light Sources

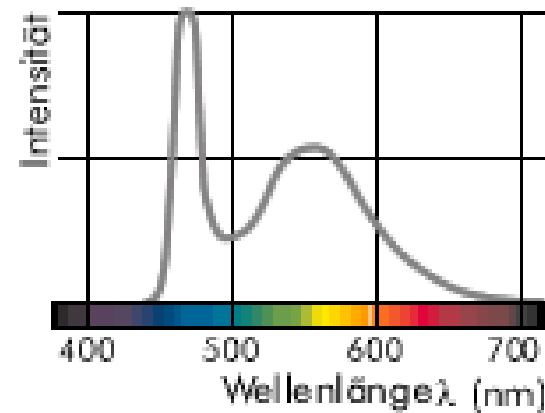
- ▶ Compared parameter: lm/W
 - Sulfur lamp 80 – 1353
 - Sodium low pressure 100 – 200
 - White LED 20 – 150
 - Energy saving lamp 35 – 75
 - Mercury high pressure 30 – 60
 - Halogen lamp 14 – 25
 - Incandescent lamp 5 – 16



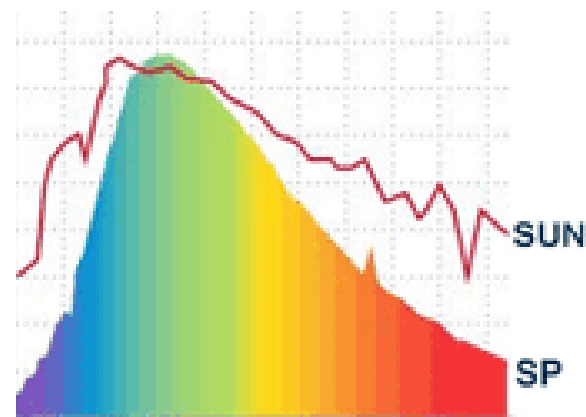
Comparison to other Light Sources



Incandescent lamp

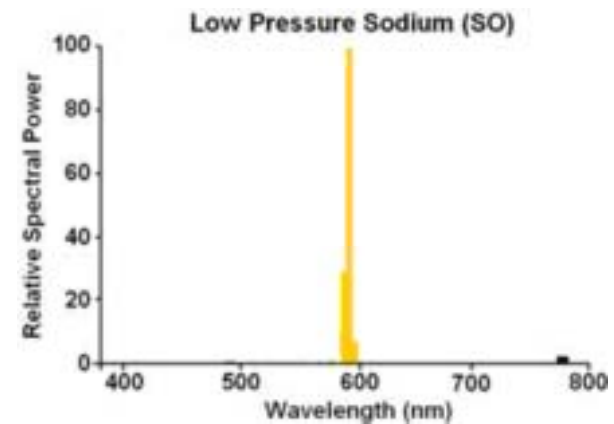


White LED



Sulfur lamp

Wiebke Dörries



The Sulfur Lamp



Application

- ▶ Light therapy
- ▶ Horticultural Research
- ▶ Light pipes → Architectural highlights
- ▶ TV studios



Application

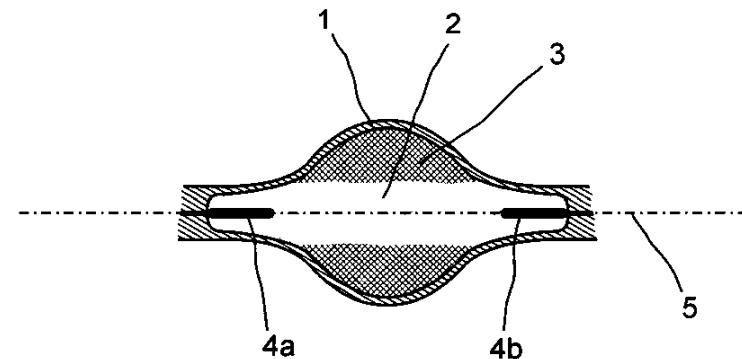
- ▶ Hill Air Force Base, Utah (1998)
- ▶ Sundsvall–Härnösand Airport, Sweden
- ▶ U.S. Air and Space Museum, Washington D.C.
- ▶ Headquarter of DONG Energy, Denmark





Research

- ▶ Cheap, efficient microwave source with long lifetime
- ▶ Low wattage sulfur lamps
- ▶ How to get rid of rotating an cooling
- ▶ Sulfur lamps with electrodes (since 2006)
 - German Patent (2011)





References

- ▶ http://eetd.lbl.gov/newsletter/cbs_nl/nl06/cbs-nl6-slamp.html
- ▶ <http://www.energieinfo.de/eglossar/schwefellampe.html>
- ▶ <http://www.wundersamessammelsurium.info/optisches/lumi/index.html#Schwefellampen>
- ▶ „Transport and equilibrium in molecular plasmas: the sulfur lamp“; C.W. Johnston; Technische Universität Eindhoven; 2003
- ▶ <http://ecmweb.com/content/rf-lighting-tunes-improved-illumination>
- ▶ http://en.wikipedia.org/wiki/Sulfur_lamp
- ▶ <http://www.plasma-i.com/index.html>
- ▶ Offenlegungsschrift DE 10 2011 012 829 A1; V. Beck; 02.03.2011
- ▶ „Plasmalichtquellen – Stand und Ausblick“; H.Hess, K.D. Weltmann; Vakuum in Forschung und Praxis; 2006, 4, pp. 7–11
- ▶ „Chemie in Lampen – Elektrische Lichtquellen“; M. Born, T. Jüstel; Chemie Unserer Zeit; Wiley-VCH-Verlag; 2006, 40, pp. 294–305
- ▶ Script „Inkohärente Lichtquelle“, T. Jüstel; summer term 2013
- ▶ http://www.led-info.de/uploads/pics/luco-led_01.gif
- ▶ <http://de.wikipedia.org/wiki/Natriumdampf Lampe>

Thank you for your Attention