The incandescent bulb: states of development

Inkohärente Lichtquellen
Ines Becker
Sebastian Schwung
The Incandescent bulb: states of development

Agenda

- Introduction
- History
- Halogen bulb
- Energy efficacy

3. Mai. 2010

Incoherent light source
Ines Becker
Sebastian Schwung
The Incandescent bulb: states of development

Principle and construction
- Black body radiation
- Electrical current heats the filament up to 2000-3200 °C

Introduction

History

Halogen bulb

Energy efficacy

1. Outline of Glass bulb
2. Low pressure inert gas (argon, neon, nitrogen)
3. Tungsten filament
4. Contact wire (goes out of stem)
5. Contact wire (goes into stem)
6. Support wires
7. Stem (glass mount)
8. Contact wire (goes out of stem)
9. Cap (sleeve)
10. Insulation (vitrite)
11. Electrical contact
Plank`s law

- The Planck law gives the intensity radiated by a blackbody as a function of frequency (or wavelength) and temperature.

\[ I(\nu, T) = \frac{2\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{kT}} - 1} \]

\[ T = 6000 \text{ K} \]

\[ \lambda_{\text{max}} \]

Introduction

History

Halogen bulb

Energy efficacy

Incoherent light source

Ines Becker

Sebastian Schwung
Incandescent bulb

- **Introduction**
- **History**
- **Halogen bulb**
- **Energy efficacy**

### 1840s
- Incandescent bulbs with platinum filament

### 1854
- Heinrich Goebel designed the first practical bulb with a carbonized bamboo filament

### 1878
- Joseph Wilson Swan developed a method to fabricate light bulbs (British Patent No 8 in 1880)
- Thomas Edison started his research into light bulbs

### 1890s
- Metal filaments are used, first osmium

### 1906
- Tungsten filaments were patented by GE

### 1911
- Developing of inert gas filling for better lifetimes

### 1960
- Halogen cycle is developed and lead to the Halogen lamps

---

Incoherent light source

Ines Becker

Sebastian Schwung
Thomas Alva Edison (1847-1931)

- American inventor, scientist and businessman

- Inventor of 1093 patents, 389 in incandescent bulb and energy
  - 1878: patent for “improvement in electric lights application
  - 1879: patent for a „electric lamp“ with a carbon filament and a improved evacuation
  - Designed a bulb holder for user friendliness
**The Incandescent bulb: states of development**

- **Introduction**
- **History**
- **Halogen bulb**
- **Energy efficacy**

---

**Filament**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1820</td>
<td>Electric current on a platinum wire</td>
</tr>
<tr>
<td>1854</td>
<td>Heinrich Goebel used a carbonized bamboo filament</td>
</tr>
<tr>
<td>1880</td>
<td>Research on many different metals like: Ta, W, Re, Os</td>
</tr>
<tr>
<td>1890`s</td>
<td>Carl Auer von Welsbach tried metal-filament mantles, in 1898 patent a osmium lamp</td>
</tr>
<tr>
<td>1906</td>
<td>General electric patent a methode of making tungsten filaments</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Material</th>
<th>Melting Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>tungsten</td>
<td>3422</td>
</tr>
<tr>
<td>rhenium</td>
<td>3180</td>
</tr>
<tr>
<td>osmium</td>
<td>3130</td>
</tr>
<tr>
<td>tantalum</td>
<td>3017</td>
</tr>
<tr>
<td>platinum</td>
<td>1772</td>
</tr>
</tbody>
</table>
Halogen incandescent light bulbs

Sublimated tungsten is transported back to the coil (Chemical transport). Bulb stays clear.

$$ W (s) + O_2(g) + X_2(g) \rightleftharpoons WO_2X_2(g) \quad T_{coil} > T_{wall} $$
Life time and brightness

→ Increase of 20 % of the normal voltage leads to an decrease of over 90 % regarding the life time.

→ oldest incandescent bulb (4 watts):
June 8th, 1901 until now
The Incandescent bulb: states of development

- Introduction
- History
- Halogen bulb
- Energy efficacy

Energy efficacy rating

![Energy efficacy chart](image)

Luminous flux (lm) vs. Electric power (W)

- A
- B
- C
- D
- E
- F
- G

3. Mai. 2010

Incoherent light source

Ines Becker

Sebastian Schwung
## EU illuminant regulation

### Incandescent light bulb

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>15W</td>
<td>15W</td>
<td>15W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25W</td>
<td>25W</td>
<td>25W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40W</td>
<td>40W</td>
<td>40W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60W</td>
<td>60W</td>
<td>60W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75W</td>
<td>75W</td>
<td>75W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100W</td>
<td>100W</td>
<td>100W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Phase-out of all clear incandescent light bulbs**

<table>
<thead>
<tr>
<th>frosted</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frosted lamps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>are displaced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>by energy-saving lamps with 'A' energy rating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Incandescent bulb: states of development

EU illuminant regulation

Halogen lamp

From September

### 2009
- 6W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2010
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2011
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2012
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2013
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2014
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2015
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

### 2016
- 5W
- 10W
- 20W
- 35W
- 50W
- 75W
- 100W

From September 2009, all frosted halogen lamps are phased out.
Exceptions

- Special lamps for refrigerators, ovens or medical purposes, spotlights
- Particular formed lamps in flashlights or vehicles
- Reflector lamps
  80 % of light output in an angle of 120°
The Incandescent bulb: states of development

Sources:

- Vorlesungsskript: “Inkohärente Lichtquellen” ; Prof. Dr. Jüstel
- http://www.vwa-deutschland.de/resources/Zeitplan+f%C3%BCr+den+Auslauf+ineffizienter+Lampen.pdf
- www.mercateo.com/.../auto_kfz_beleuchtung.gif
- http://www.bund.net/bundnet/themen_und_projekte/klima_energie/stromfresser_stopp/gluehlampenverbot/
- http://de.wikipedia.org/
- http://scienceworld.wolfram.com/physics/PlanckLaw.html
- http://www.manufactum.de/Artikel/85164/.
- de.academic.ru
  - www.lightbulbjourneys.com

3. Mai. 2010
Ines Becker
Sebastian Schwung
How many professors does it take to change a light bulb?

Only one, but they get three technical reports out of it.

How many students does it take to change a light bulb?

I don’t know, I forgot my calculator at home.