UHP Lamps for Projection Systems

Pavel Pekarski, Ulrich Hechtfischer, Gero Heusler, Achim Koerber, Holger Moench, Jens Pollmann-Retsch, Ulrich Weichmann and Arnd Ritz

Philips Research Laboratories, Weisshausstr.2, D-52066 Aachen, Germany

Projection systems have reached a convincing performance relying on the outstanding properties of the UHP lamp. In our presentation we discuss the UHP concept as well as the topics of lamp ignition and the electrode stability during the lamp's lifetime.

1 INTRODUCTION

Short arc lamps are a key component for projection systems to achieve highest efficiency for small display sizes. Looking back, the introduction of the UHP lamp (**U**ltra **H**igh **P**erformance) concept by Philips [1,2] gave the projection market a significant technological breakthrough. UHP lamps today are the standard for most commercially available front and rear projectors. The combination of highest brightness with lifetimes extending up to more than 10000hrs is ideal for the projection application.

2 THE UHP LAMP CONCEPT

2.1 High Luminance and Continuous Spectrum

An average arc luminance >1 Gcd/m^2 is necessary for high efficiency projection with today's small size displays. Such a high luminance can be produced with rare gas discharges (but low efficacy) and with pure mercury discharges. The maximum luminance that can be reached in thermal equilibrium is physically linked to the discharge temperature by Planck's law. Metal halide additives, which have been used in the past to improve the lamp spectrum, lower the discharge temperature and thus radiate at much lower luminance. Therefore the UHP lamp contains only mercury as radiating species.

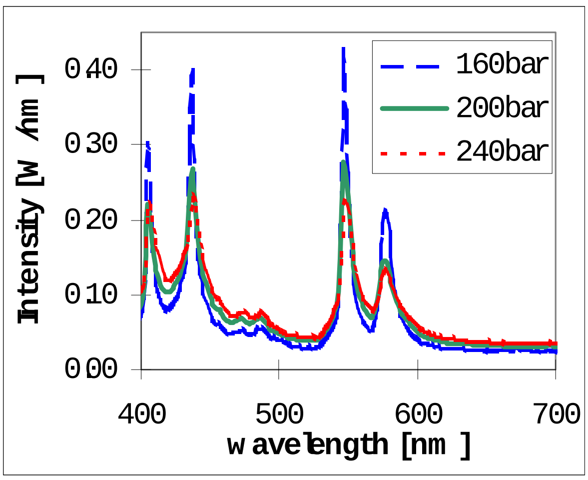


Figure 1: Measured UHP spectra of 1.3 mm lamps at 100 W depending on the mercury pressure.

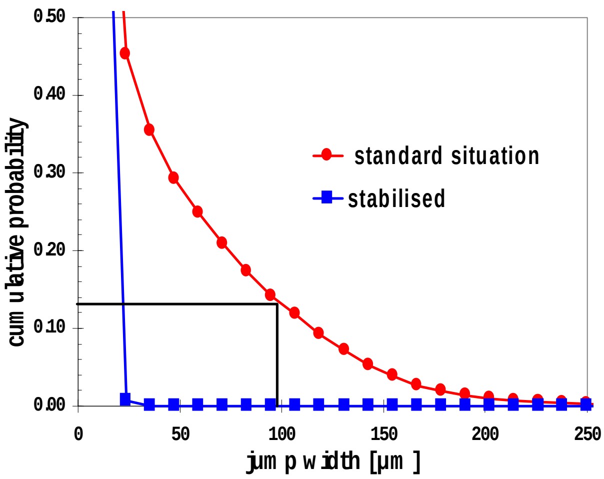
A very high operating pressure of more than 200 bar is used to reach a high burning voltage of the lamp, despite the short arc gap. For mercury pressures above 200 bar more light is emitted in the continuum radiation than in the atomic spectral lines (fig.1). Especially the red light above 595 nm strongly depends on the lamp pressure. The lamp with 160 bar (fig.1) gives 20% less red light than the >200 bar UHP lamp. For good color balancing in projection systems it is therefore essential to realize ultra high lamp pressures.

2.2 Regenerative Chemical Cycle

UHP lamps can reach lifetimes of more than 10000 burning hours enabled by the regenerative chemical cycle using a patented halogen filling [1,2]. Adding a certain amount of oxygen and halogen to the lamp atmosphere prevents the tungsten evaporated from the lamp electrodes to condense on the wall, as in the colder regions the tungsten atoms react chemically to form oxyhalide molecules.

2.3 Stable Arc

The electrodes of short arc lamps change their shape after some ten or hundred hours of operation. The arc plasma will change its attachment on this rough surface frequently (fig.2). The moving arc affects the light distribution on the display and therefore causes disturbing brightness variations on the screen. Philips



has introduced the first solution to stabilize the arc during the whole lifetime of the lamp. This has been realized in the UHP-S™ electronics using a specially designed lamp current [3]. The solution is closely related to the interaction of driving mode and arc attachment. Contrary to the standard "block" form current shape, the application of the special current form with extra current pulses at the end of each half-wave results in a stable arc attachment on the electrode over the whole lifetime.

3 LAMP IGNITION PHYSICS

To create a gas discharge, primary electrons are needed. All charge carriers in a lamp which has been switched off for a while are neutralized. Primary electrons can be produced statistically by natural radioactivity, but for a small volume of UHP lamp it is unlikely that this will happen right at the time the lamp should ignite. Traditionally the primary charges are created via field emission of electrons from the electrodes. Due to the modifications of the electrodes during their lifetime we cannot rely on sharp edges and the corresponding high field strengths but have to apply 20kV to the lamp for a save ignition. Alternatively electrons can be also produced via the photoeffect on the tungsten electrodes. As the work function of tungsten is 4.54eV we need photons of higher energy, i.e. UV radiation with $\lambda < 270nm$. This UV radiation can be produced by an ignition aid which is often called UV-enhancer and is basically a small lamp that incorporated into the sealing of the UHP burner [4,5]. Some millimeters in the middle of one sealing are not closed leaving a small cavity with the molybdenum foil going through it. An external wire (“antenna”) creates an electrical field and a first ignition takes place inside this small cavity. Thanks to the sharp edges of the foil much lower voltages can be used to extract electrons. A capacitive discharge between the foil and the antenna is operated in the UV-enhancer and a part of the produced photons is conducted along the sealing by total internal reflection towards the main burner cavity. There they have a chance to create electrons and the discharge also starts in the main cavity.

Once a primary breakdown has been achieved the lamp requires voltages of only a few hundred volt in a glow state and below hundred volts when the arc has established (<1s).

Sometimes a “hot-restrike” of the lamp is necessary, only a few seconds after switching it off. Although plenty of charges still exist at this time high voltage is required to create a breakthrough in the high-pressure gas. A metal wire close to the burner as indicated in fig.3 can modify the field distribution inside the burner cavity and helps to lower the required restrike voltage. The field forming wire can be combined with the antenna around the UV-enhancer as indicated in fig.3.

The UV-enhancer guarantees low ignition voltages for the larger off-times. Even after days in total darkness the lamp ignites safely at voltages much below 5kV.

The implementation of the UV enhancer into the sealing of the UHP burner and the combination of the antenna for the UV enhancer and the field formation inside the burner allows an extremely compact product.

The system is operated in combination with a lamp driver which works with only 5kV ignition voltage. This allows a smaller and less energy dissipating induction coil. The choice for 5kV was made to guarantee hot restrike in less than a minute even without cooling.

In addition to the smaller driver the lower ignition voltage allows a more compact projector design around the lamp. Insulation distances in air are required in the order of 1mm/kV. The achieved reduction from 20kV to 5kV corresponds therefore to a size reduction of 15mm. The design of a compact projector clearly profits from this “invisible” size reduction.

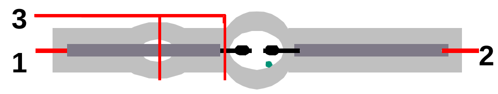


Figure 3: Schematic drawing of an UHP burner and the UV-enhancer cavity in the left sealing. The additional antenna-wires (3) are electrically connected to the electrode (2).

4 CONCLUSIONS

The demands of projection systems towards small displays, miniaturized systems and finally bright projected images on the screen are well matched by the UHP lamp technology. The trend to increase the optical requirements to the light source will continue, however, demanding for an even shorter arc length and higher Hg pressures. A significant reduction in arc size from 1.3 mm to 1.0 mm has been already realized for most UHP types, a further step will follow.

5 REFERENCES

[1] E.Fischer and H.Hoerster, High Pressure Mercury Vapour Discharge Lamp, US-Patent 5109181

[2] E.Fischer, Ultra High Performance Discharge Lamps for Projection TV Systems, 8th Int. Symp. on Light Sources, Greifswald, Germany, 1998

[3] H.Moench, G.Derra, E.Fischer, X.Riederer, Arc Stabilization for Short Arc Projection Lamps, SID 2000

[4] H.Moench, G.Derra, E.Fischer, H. de Regt and X.Riederer, New Development in Projection Light Sources – Shorter Arcs and Miniaturisation, SID 2001

[5] H.Moench, G.Derra, E.Fischer and X.Riederer, UHP Lamps for Projection, Journal of the SID, vol 10, nr 1, 2002