XENON AND/OR LEDs AT HEADLAMPS

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ABSTRACT

This paper presents the operation and specification of gaseous discharge lamps and light emitting diodes applied at the headlamps of road vehicles. On the end it is presented a comparison of different light sources.

Keywords: headlamp, Gaseous Discharge Lamp, LED

1. XENON at headlamps

It is well known that xenon is a chemical element, but it is also a wild spread phrase for the so called gaseous discharged lamp (GDL) applied at headlamps of the vehicles. It was applied to increase the efficiency of the headlamps, to get higher light intensity from a smaller light source.

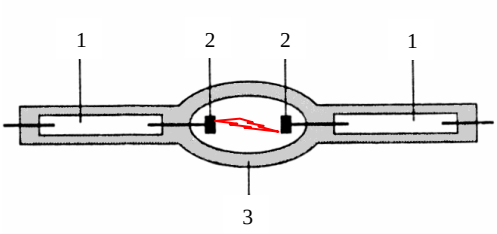


Fig. 1. Structure of gaseous discharge lamp (GDL)
1 - wires, 2 - electrodes, 3 - body [1]

The distance between electrodes is equal to the length of the filament of the incandescent lamp (bulb) and it is 4 mm. The GDL is filled in by metal-halogen salts nearby xenon gas. To produce the arc it is needed (10…20) kV DC, but to keep it it is necessary 85 V AC. It reaches its maximal intensity after 0.5 s, but in 0.3 s reaches the specific value of halogen bulbs. The current starts at 2.6 A, but afterwards it is only (0.3…0.6) A. The high-temperature arc heats the xenon gas that evaporates the metal-halogen salts. This process gets stabilized in 3 s. The colour temperature of the arc light is about 4200 K. It approximates well the properties of the natural light, and it is continuous in the range of sensitivity of the human eye. The efficiency of GDL is about 85 lm/W that is three times higher than the efficiency of a halogen bulb applied at headlamps until now at the most of road vehicles. In case of failure the GDL does not suddenly go out, but gradually decreases its intensity and in this way the problem can easily be diagnosed. Their life time is around 1500 h that rivals to the life time of the vehicles.

Application of GDL needs special control. This is the reason why this system is called Litronic that comes from the combination of English words Light and Electronic.

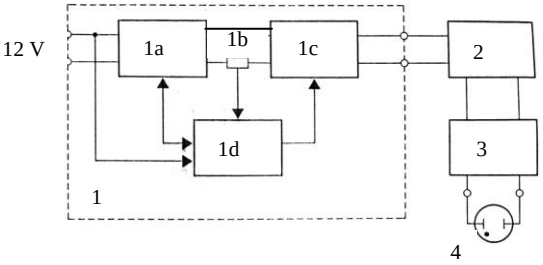


Fig. 2. Block scheme of the control of GDL [1]
1 - ECU (electronic control unit), 1a - DC/DC converter, 1b - shunt, 1c - DC/AC converter, 1d - microprocessor, 2 - ignition unit, 3 - socket, 4 - GDL

The second generation of GDLs are equipped by high-voltage proof sockets and UV-filter glasses. Firstly the GDL was developed only for high light intensity low beams. Bi-xenon GDLs have been already developed similar to double filament bulbs and now GDL can be applied at dual headlamps for low beam and high beam as well.

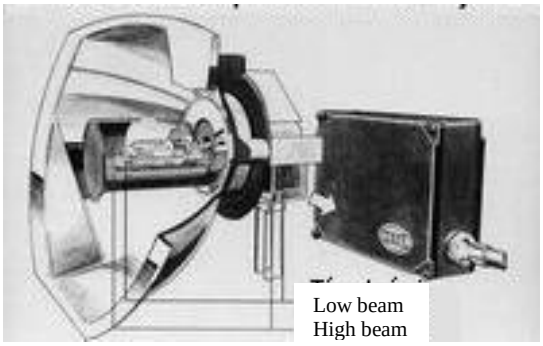


Fig. 3. Bi-xenon headlamp [1]

The regulations prescribe that only such kind of xenon light system can be installed that can keep the inclination angle constant regardless to the

load of the vehicle. In this way it is reduced the danger of the blinding of the front coming vehicles.

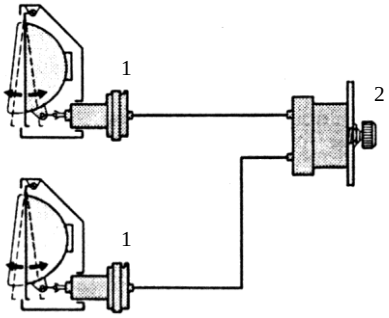


Fig. 4. Manual vertical-aim control [1]
1 - actuator, 2 - adjustment switch

The manual control contains the subjectivity of the driver. The exclude this inconveniency an automatic control was developed.

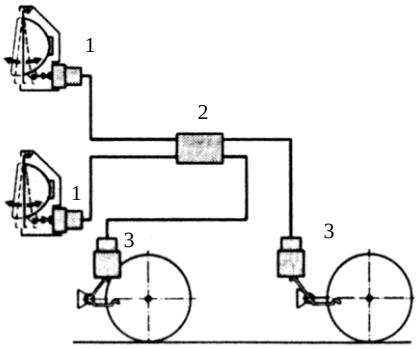


Fig. 5. Automatic vertical-aim control [1]
1 - actuator, 2 - control unit, 3 - level sensors

Nowadays we can meet the combination of different kind of headlamps.

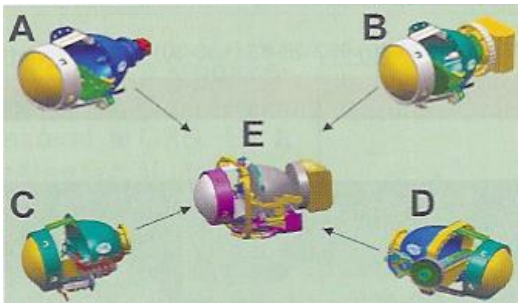


Fig. 6. Combination of different kind of lamps [2]
A - halogen lamp, B - GDL, C - Bi-xenon lamp,
D - vario-xenon lamp,
E - combined lamp with two axis actuator

The combined headlamps insure a better visibility to the driver by the fact that they can face to different traffic situations such as: curves, joints, fog, motorway nearby the traditional low beam and high beam functions.

2. LEDs at stop stop lamps

LED is an acronym, coming from the words Light Emitting Diode. This is a small, law consumption and quit cheap electronic device, used generally at entertainment electronic apparatus. LEDs were used at vehicles as the third stop lamp, because a LED lights up 0.2 s earlier then a normal incandescent lamp that means 5 m advantage in the braking distance at highway speed. Furthermore LED does not need mirror built in the lamp. This means that its dimensions can be extraordinary small and it gives a good possibility to build it in to small spaces in the back of the rear window or spoilers [1]. The normal LED were not suitable to be applied because theirs low light intensity.

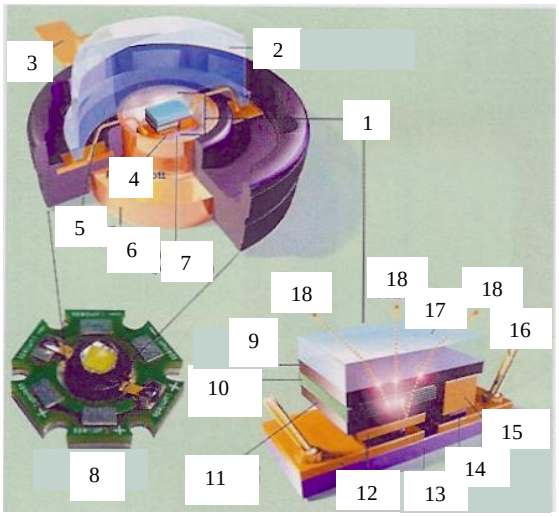


Fig. 7. Structure of LED applied at vehicles [2]
1 - LED chip, 2 - plastic lens,3 - cathode, 4 - soldered joints, 5 - gold wire, 6 - copper heat sink, 7 - insulating silicone, 8 - LED itself, 9 - n-type gallium nitride, 10 - quantum storage layer, 11 - p-type gallium nitride, 12 - metal contacts, 13 - insulated base, 14 - soldered joints, 15 - metal contacts, 16 - gold wire, 17 - sapphire, 18 - photon

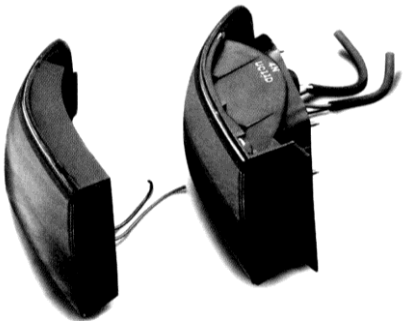
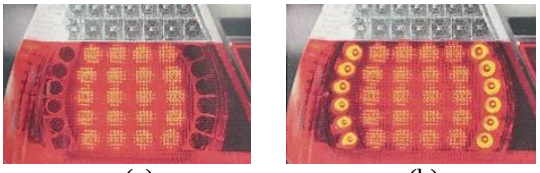


Fig. 8. Back lamps:
LED and normal technology [2]

The breakthrough was taken by the optoelectronics division of Hewlett Packard in 1996 introducing the aluminum-indium-gallium-phosphorus semiconductor technology.

Nowadays, more and more car manufacturers apply the new light source, not only because of the importance of road safety and aesthetic considerations, but also for its low price and low energy consumption, that is 80% lower than the consumption of the corresponding incasdenscent lamp.



(a) (b)

Fig. 9. Two level stop lamp [2]
(a) light and normal braking, (b) hard braking

Fig. 10. LED lamps with bayonet socket like for stop or turn-signal lamp bulb [2]

3. LEDs at head lamps

Firstly, the LEDs where applied only for side-markes and low beam lamps.

Fig. 11. Side-marker and low beam lamp with LEDs [2]

Later on there were studies concerning to develop high beam head lamps applying LEDs only. At this headlamp concept there were used 9 LEDs at each head lamp (low and high beam) on the both sides separately.

Fig. 12. Head lamp concept with LEDs [3]

The blue emitting semiconductor was covered by yellowish light powder to achieve a better radiation spectrum. In such a way it was obtained a white LED with color temperature between 6000 K and 8000 K. The power of each LED was 5 W.

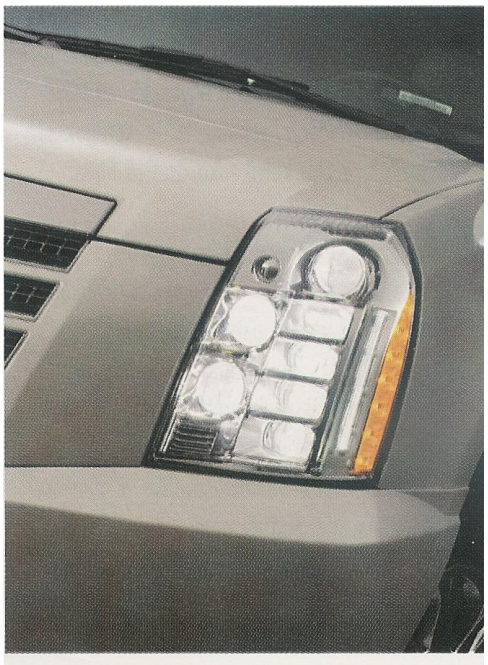


Fig. 13. The completely LED headlamp of Cadillac Escalade Platinum by Hella [4]

In the case of power LEDs applied at above mentioned headlamps an important factor is the heat that should be taken out from the system. So, nearby the electronic control unit that drives the LEDs (LDM = LED driver module) a special cooling unit is needed. The LEDs are built on aluminium heatsinks and a ventilator insures the cooling air.
The headlamp presented in the next figure consists 71 LEDs with a colour temperature of 5500 K. The adaptive headlamp has a special actuator that is controlled by an electronic unit to resolve not only the aim-control, but to set it for different traffic situations.

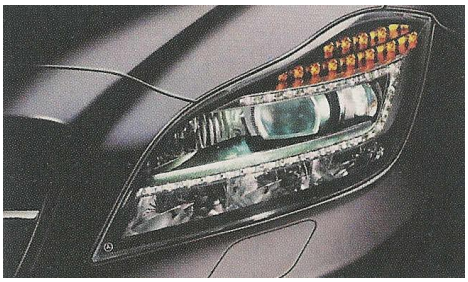


Fig. 14. Red Dot Design Award 2011 for the fully LED headlamp of Mercedes CLS designed by Magnetti Marelli [2]

4. Comparison of different light sources

Taking into consideration some literatures we can make an idea about the behaviour of different light sources and see how they relate to each other on the base of their specifications.

The colour temperature of different light sources is presented in the next figure. Around the Planck line it can be observed the area defined by ECE/SAE concerning to headlamp sources.

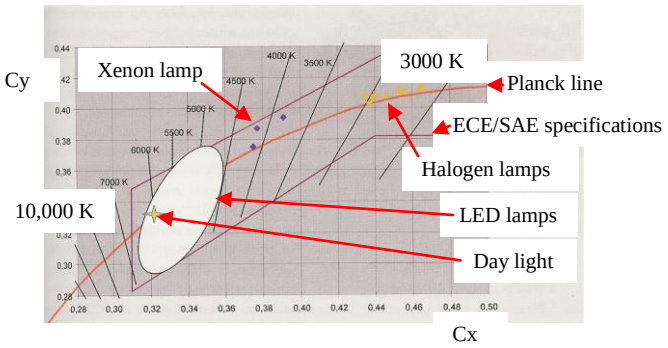


Fig. 15. Colour temperature of different lamps [2]

The metal-halogen components gives a spiny shape to the light spectrum of GDL against to LED that has smoother shape.

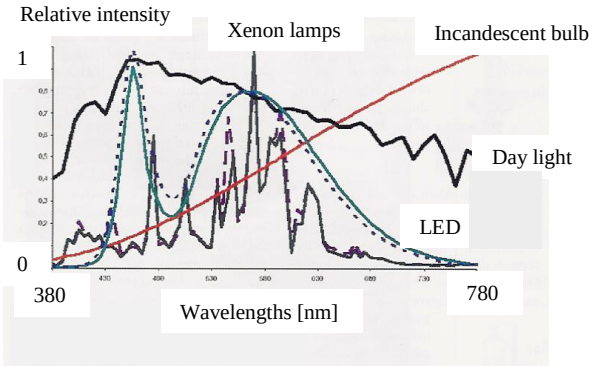


Fig. 16. Light spectrum for different lamps based on the work of Manz [3]

Nearby very good spectral specifications there is possible to modulate the supply current of LEDs by higher frequency signal that can not be perceived by the human eyes. In this way there is possible to change information, so a good solution for communication with other cars and transmitter-receivers nearby the road.

Some examples: switch between high beam and low beam, enable or disable for overtaking, braking information, invisible obstacle in curves, automatic remote control of garage door, etc.

Table 1

Comparison of different lamps [1], [2]

Characteristic	Halogen	Xenon	LED
Colour temperature	3000 K yellow	4500 K blue	6-8000 K day light
Freedom of designers	low	low	high
Number of components	medium	high	low
Efficiency [lm/W]	22 … 26	85 … 90	100...150
Consumption	high	medium	low
Life time	low	medium to high	high

5. Conclusions

Now the most promising light source is the LED, because it has the best specifications as the light spectrum, efficiency, life time, communication, price, but also present some difficulties concerning to the heat. Hope to meet LED headlamps at more and more road vehicles.

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