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New light sources and their requirements of the reflector materials

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1. Historic overview of light reflectors

The history of lighting has witnessed the development of new light sources generally leading to changes in the characteristics of reflectors, which translated into changes to reflector geometry or to the materials used. In the case of the light bulb or energy-efficient bulbs, the reflectors were principally fashioned from paper, textiles or plastic foils, whereas workplace fluorescent luminaires mainly consist of anodized or PVD-coated reflective aluminum elements assembled into a panel in order to comply with DIN 5035 and EN 12464-1 (standards for interior workplaces).

Using LED technology in office environments creates a new set of requirements for reflector material. Glare suppression and light diffusion represent particular challenges in terms of precision and also the long-term stability and operational life of the reflectors.

2. Function of the reflector

The reflector connects the light source with the area to be illuminated and, depending on the environment and lighting requirements, the reflector will need to perform the following functions:

- light diffusion, light distribution, light guiding, glare suppression
- filtering the light spectrum (UV/ IR absorption)
- heat management (cooling, heating)
- aesthetic requirements (design)
- electrical / electromagnetic shielding
- protection of the light-source against mechanical impact
- sustainability: energy efficiency, energy saving, operational life

3. Light sources and reflector materials

Almost all categories of rigid materials have been used in reflectors: metals, glass, (transparent) plastics, paper, textiles. We can also add to the list PVD[1] – coated systems, which usually provide increased reflectivity due to their wave-length sensitive properties.

The following table contains examples of some reflector materials commonly used in lighting. Alongside optical performance, thermal conductivity and thermal capacity are new and significant factors which need to be considered in the case of LED lighting. Heat management of sensitive electronic light sources is the greatest challenge for materials which has arisen in developments to date

Reflector material	**Total reflectivity (DIN 5036-3)**	**Light -directing/ -diffusion**	**Thermal conduc-tivity W/mK**	**Thermal capacity kJ/ (kg.K)**	**el. magnetic shielding**	**Fire beha-vior [2])**
Aluminum (raw, anodized)	80 - 90	diffused - directed	236	0.9	yes	A1
Aluminum (RE) enhanced reflectivity	95 - 98	diffused - directed	236	0.9	yes	A1
Stainless steel	50 - 60	matte-directed	15 - 80	0.46	yes	A1
Steel – painted white	80 - 90	diffused	15 -80	0.46	yes	A1
Silver (polished)	95	directed	429	0.23	ja	A1
Silvered glass mirror	95	directed	0,19	1,47	yes	A1
Glass 1)	92	transparent opaque - diffused	0,19	1,47	no	A1
Acrylic glass 1	86		0.2	1.25	no	B2
Polycarbonate (PC) 1)	80 - 90		0.14	1.2	no	B1
Paper (white)	80 - 85	diffused	0.18	1.2	no	B3
Textiles 1)	50 - 80	diffused	0.04	1.7	no	B2 – B3

[1]) transparent materials= Transmission coefficient
[2]) building material classes DIN 4102 - 1

Tab. 1: Properties of reflector materials

4. The “ideal” LED reflector

LED lighting, with its high density of point-source light emission places considerable technical demands on the reflector, due to the degree of miniaturization and the heat-sensitivity of these electronic components. We have set out below a reflector design which addresses a number of the requirements:

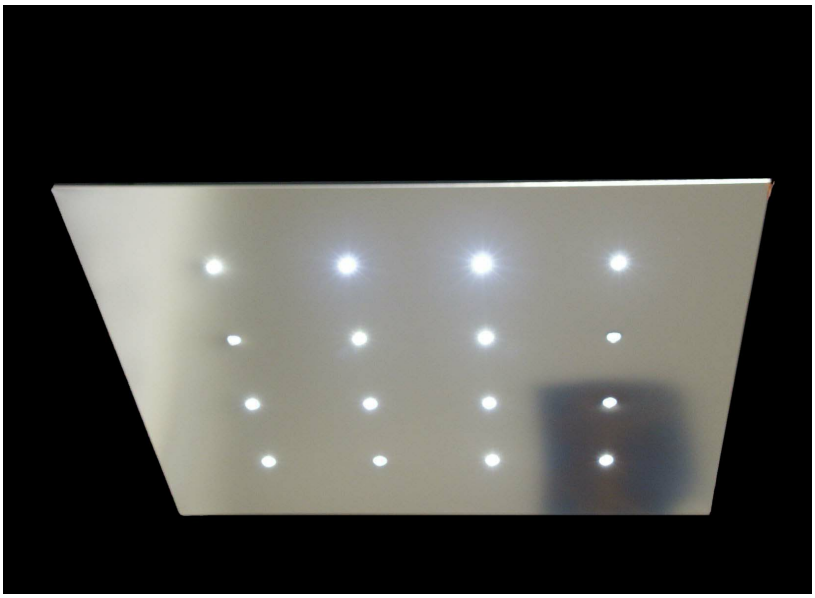
A LED light consists of a high-grade and highly-reflective aluminum plate in which the mini-reflectors directing the light are configured as “downlights” and serve to both diffuse light and suppress glare. The surface of the aluminum plate in the “downlight area” has been coated to

maximize reflectivity which ensures high luminous efficiency. The high-performance LEDs with over 3 Watt / LED are mounted directly onto the reflector, in order to minimize thermal transfer resistance.

The aluminum base plate housing the mini-downlights, and with high heat conductivity, is connected to an aluminum backing sheet which results in a stable, rigid yet thin lighting panel. The two sheets are connected, in this sandwich-like construction, by a thermally conductive core material. The surfaces of the approximately 65cm x 65 cm LED panels are coated to emit heat and thus a large proportion of the heat generated is dissipated into the surrounding area. New printing and coating techniques mean electrical supply leads can be applied directly onto reflector components, thus achieving considerable savings in wiring.

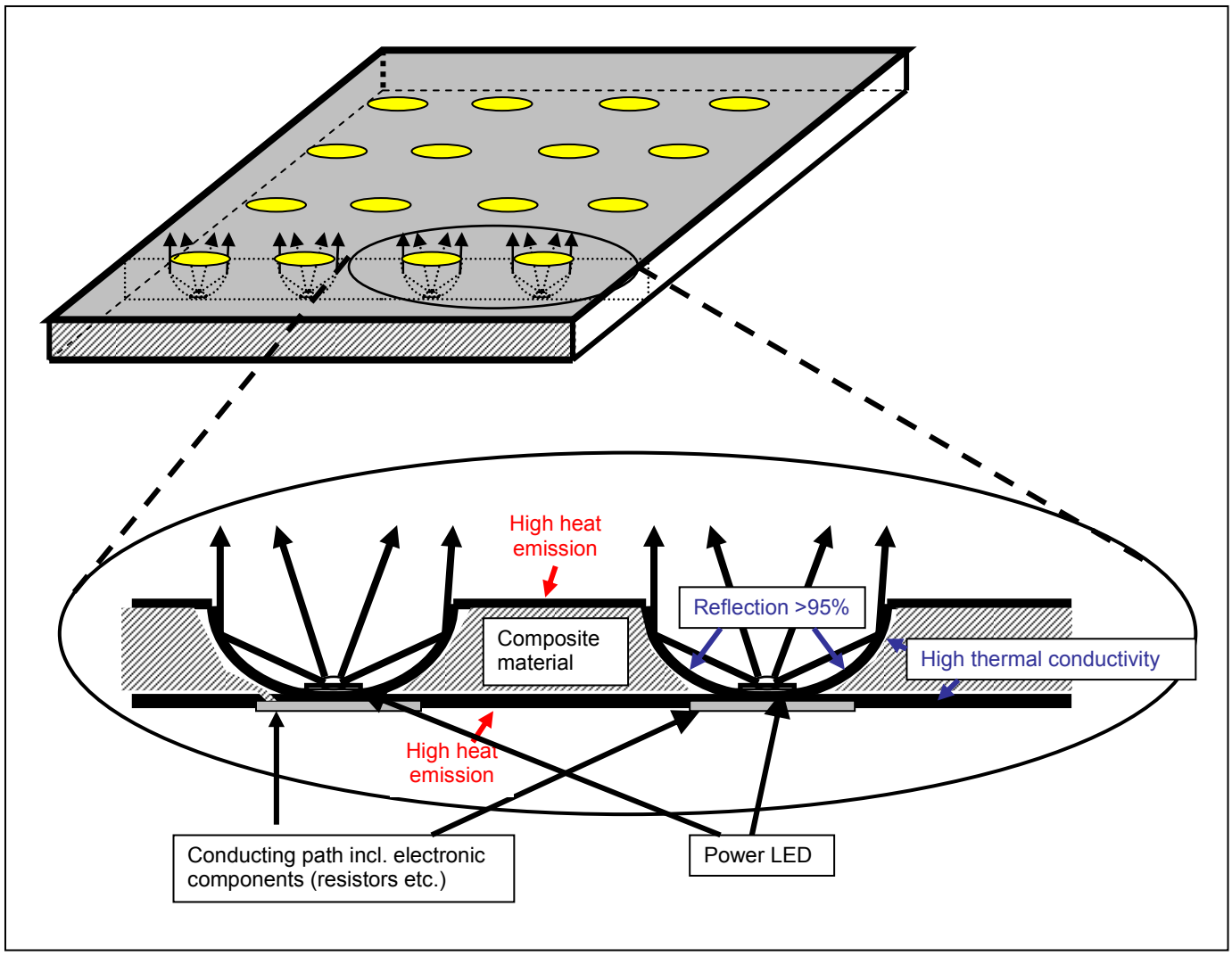
Table 2 lists the reflector functions and requirements seen earlier.

Reflector- functions and requirements	**Notes**
High reflectivity (front side)	ideally R > 95%
UV / (IR) absorption	
Precise light diffusion and glare suppression	Complies with EN 12464-1
High emission, highly efficient heat-radiating surface (reverse / back side)	ideal > 80% of the black body radiation
Low thermal transfer resistance between LED chip / reflector via direct solder application	Thin layer of insulation between LED chip and circuit board
High thermal conductivity	> 200 W/mK
Self-supporting / mechanically stable / minimal depth	ideal depth < 15mm
Integrated wiring	e.g. on back/reverse
Sustainability / good recyclability	
Operating life	depends on whether for indoor or outdoor use



Picture 1: „ideal“ LED reflector

Depending on the angle from which it is viewed when seen close up, the lighting panel prototype, made from highly-reflective aluminum, shows the glare reduction capability of the downlights acting as mini-reflectors



Picture 2 is a sketch of the LED- lighting panel.

5. New light sources without a reflector (OLED)?

A great future is being predicted for these organic LED lights, including for their use in technical lighting applications. In both the popular scientific press as well as in specialist publications, OLEDs are being hailed as 100% shadow-free diffuse light sources which do not need a reflector.

If you consider the products currently on the market, with their low light density, then this assessment is no doubt accurate. However, if increases in light yield are achieved at the same pace as during the development of LEDs, heat dissipation, light diffusion and glare suppression may also become challenges for these wide-area light sources, too.

Watch this space!