

Seeing and being seen: optical elements for LED headlamps made of PLEXIGLAS® and PLEXIMID® molding compounds

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Materials used as optical elements in car headlamps must satisfy stringent requirements on light transmittance, temperature resistance, and UV resistance—as in the case of the three PLEXIGLAS® and PLEXIMID® molding compounds in the LED Intelligent Light System from Automotive Lighting, which Mercedes-Benz is installing in its C-Class.

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Headlamps add distinction to the front of a car, illuminate the road surface, and make the vehicle visible to other road users. In the LED Intelligent Light System of Automotive Lighting, which Mercedes-Benz is installing in its current Mercedes-Benz C-Class, three different PLEXIGLAS® and PLEXIMID® molding compounds are used. Source: © Daimler AG

Drivers must be able to react promptly to dangerous situations even in poor light or darkness, which is why car makers and suppliers are using ever more powerful illuminants. Whether halogen technology, xenon light, or LEDs, they all have one thing in common: The illuminants need a surrounding material that targets their light on to the road. In headlamps this function has long been performed by profiled cover lenses. Nowadays light distribution is by means of numerically calculated free-form reflectors or sophisticated projection modules directly in the headlamp. These are therefore distinguished by esthetically attractive clear cover plates.

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Intelligent Light

“The different functions of a headlamp place different requirements on the material used,” explains Klaus Kratschmann, responsible for ID at Automotive Lighting. In the LED Intelligent Light System, for example, which has been producing Automotive Lighting for Mercedes since 2013, two projection modules jointly take over the low beam function. The flexibility of these modules exceeds the possibilities offered by xenon light: For example, light distribution is adjusted according to the car’s speed and the ambient situation. “The headlamp illuminates the road surface in a situation-specific way,” says Dr. Ernst-Olaf Rosenhahn, in charge of headlamp innovations at Automotive Lighting. For this purpose the modules are fitted with LED arrays, optical heads, and a projection lens made of PLEXIGLAS® Heatresist FT 15. “The material offers optimal light transmittance for our application,” says Henning Weinhold, lighting engineer at AL. In addition, branded polymethyl methacrylate (PMMA) from Evonik prevents the occurrence of optically disturbing color fringes from the periphery of the lenses. The reason is the low optical birefringence of the material and its simultaneously high Abbé number, ensuring that dispersion effects are kept to the minimum.

Moreover, PLEXIGLAS® is absolutely colorless and transparent—which points to another characteristic of LEDs: They offer a light color similar to that of daylight and are therefore kinder to the driver’s eyes. This optical quality is maintained in PLEXIGLAS® over the long term. Even after several years, the material does not lose its high transmittance and offers a consistently high light yield. Nor is it affected by the high temperatures prevailing in headlamps.

Withstanding heat

For all their advantages when used in headlamps, LEDs also put the material used in them to a hard test: Depending on the type and design of the optics, temperatures of well over 100 degrees Celsius could arise, and over long periods of operation.

But light covers, lenses, and lightguides must not deform, discolor, or become opaque. “And that really can’t be taken for granted in transparent plastics: Materials like polycarbonate and even its temperature-resistant variants yellow over time. This reduces light yield and optical brilliance is lost,” says Martin Mohrmann, senior technical marketing manager Automotive at Evonik. Specialty PLEXIGLAS® molding compounds, on the other hand, are optimized for various temperature requirements; PLEXIGLAS® Heatresist FT15, for example, withstands heat stress in the projection modules without any problem.

Suitable for even higher temperatures is the specialty molding compound PLEXIMID® or polymethylmethacrylimide (PMMI), to give it its correct chemical name. It remains entirely stable under long-term thermal stress: Barely any changes occur in transmission, yellowness index, or opacity in a 40-day endurance test at 150 degrees Celsius. For this reason it is used in many headlamps of the current Mercedes-Benz series as a lightguide in the curved, torch-shaped daytime running lights. In this component the LEDs are placed very close behind the lightguide, so that temperatures very quickly rise as high as 130 degrees. With PLEXIMID® the light yield remains consistently high even after many years. “This is important because daytime running lights allow the car to be seen clearly by other road users,” explains Mohrmann.

Homogeneous appearance

Also contributing to visibility are the indicators, which in the LED Intelligent Light System consist of six individual optical elements. The special feature here is that the designers have decided against a colored light cover, choosing instead the clear standard PLEXIGLAS® 8N molding compound. This has a satisfactory heat deflection temperature, appropriate to the relatively low thermal stress in this component. “It was important to us to create for the Mercedes-Benz C-Class puristic, reduced contours that emphasize its intelligent engineering,” says Stefan Handt, head of Exterior Design, Lights & Parts at Mercedes-Benz.

Because the LEDs of the flashing light emit yellow light, we were able to dispense with a colored light cover for the direction indicator, using instead clear PLEXIGLAS®, which transmits colors faithfully. This enhances the overall appearance of the headlamp.” The headlamps thus give the Mercedes-Benz C-Class its distinctive face, typical of the brand. This is one car that will undoubtedly be seen and recognized.



Clearly etched headlamp contours mark the distinctive face of the Mercedes-Benz C Class that is typical of the brand. © Daimler AG



For a homogeneous overall effect the designers chose colorless materials, even for the indicators. © Daimler AG

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