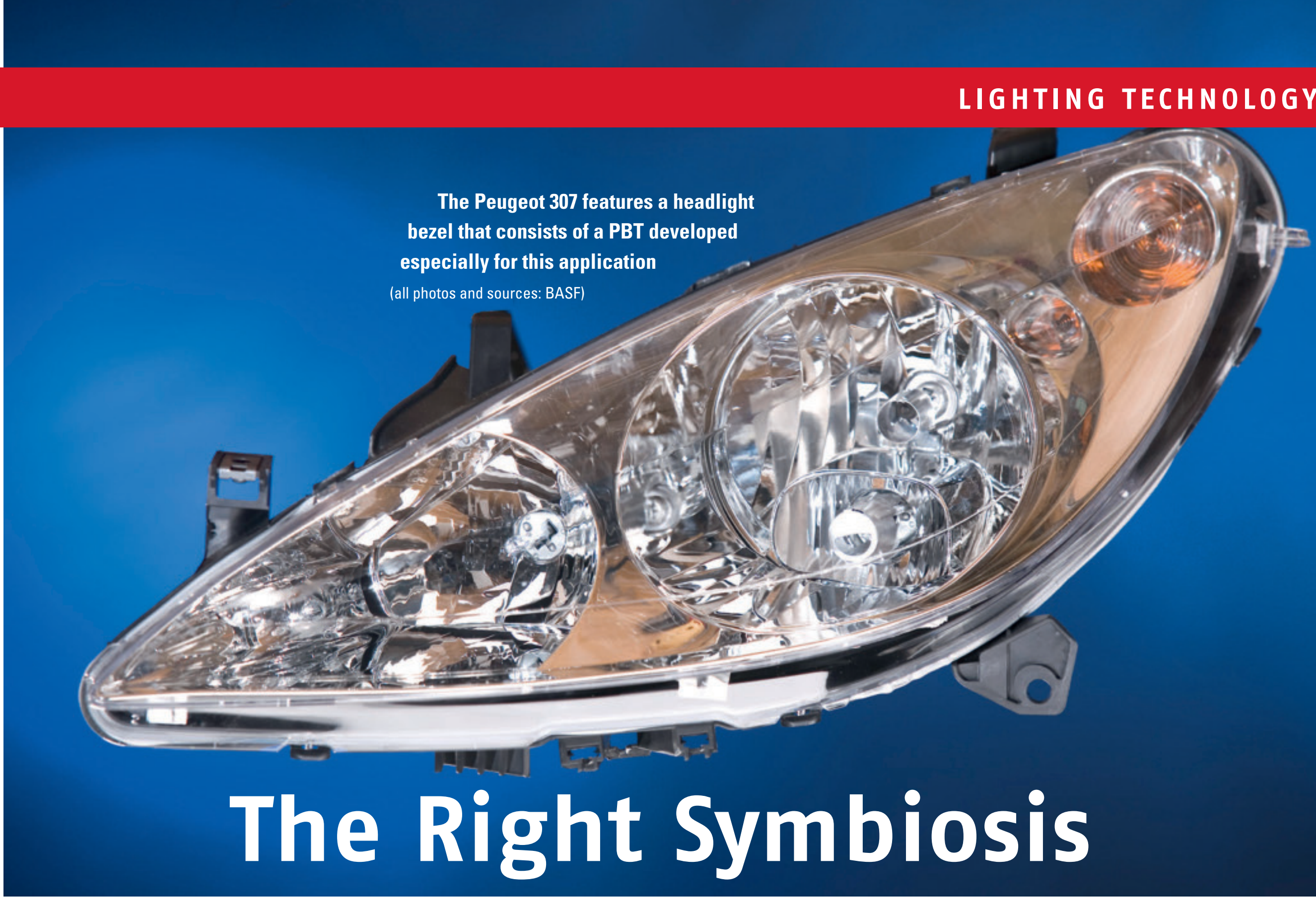

The Peugeot 307 features a headlight bezel that consists of a PBT developed especially for this application
(all photos and sources: BASF)

The Right Symbiosis

High-performance Plastics in Headlights. Advanced features and more design freedom are currently the strongest trends in vehicle lighting systems. Newly developed thermoplastic grades based on PBT and PESU offer innovative solutions for the high functional and aesthetic requirements.

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The development of front headlights is dictated by two trends nowadays: the integration of new functions, such as cornering lights, and the use of the headlights as a design element. Front headlights especially are growing larger and more prominent and so playing a bigger role in the overall appearance of the car. At the same time, new lighting technology is coming on stream, such as high-performance xenon HID headlights (high-intensity discharge) and high-performance LEDs (light-emitting diodes). Xenon systems are characterized by a very bright light. LED lamps are already in use for rear lights; work has been ongoing since 2004 on incorporating high-performance LEDs into front headlights. Both systems consume less energy than conventional lighting systems. Nonetheless, the heat generated still has to be managed.

These trends and technologies have created a necessity to optimize processing, thermal management and surface quality of the thermoplastics employed, such as polyethersulfone (PESU; grade: Ultrason) and polybutylene terephthalate (PBT; grade: Ultradur). The stringent requirements are met by three new BASF products from these two classes of material presented below. Two new products made from Ultrason high-performance plastic for reflectors greatly extend the scope for using PESU in headlights: Ultrason E 2010 MR Black HM for improved heat management and Ultrason E 2010 MR HP, a PESU blend that has been optimized for toughness and processing. Ultradur 4560, designed specifically for headlight bezels, taps into an application area for a high-performance PBT that was previously the preserve of materials such as polycarbonate (PC) and polyamide (PA).

Pigmented PESU Dissipates Heat

Typical front headlight applications of the amorphous plastic PESU are fog lamp reflectors, housings and frames. Opaque, mostly black-pigmented materials are used for housings, and, depending on the shape, to some extent for reflectors. Black-pigmented plastics have the advantage of requiring less pigment and thus yield a better surface. A disadvantage is that black materials are worse at transmitting thermal radiation. Heat dissipation in headlights therefore poses a challenge to material developers. The highest temperatures occur naturally above the lamp. With black materials, especially, total absorption of heat radiation occurs already on the surface. If the heat is not dissipated fast enough, heat buildup occurs. One

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Fig. 1. The new Ultrason E2010 MR Black HM, a polyethersulfone, reduces heating up of front headlights by virtue of its integrated pigment system

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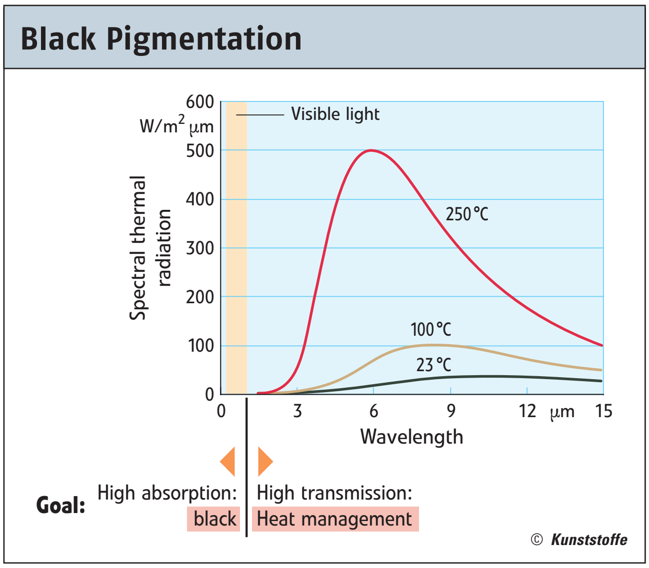

Fig. 2. Ultrason E2010 MR Black HM attains the maximum possible absorption and thus a black color below 1 µm, at the wavelength of visible light. Above 1 µm transmission is high and so heating is minimized

approach to counter the buildup would be to increase the thermal conductivity while another would be to decrease the wall thickness. However, higher thermal conductivity can be achieved only by adding fillers and is thus gained at the expense of surface quality. And, a reduction in wall thickness is severely limited due to the flow properties or the specified part rigidity. For the same reasons, there is little scope for improving ventilation and thus cooling. A new PESU (grade: Ultrason E 2010 MR Black HM; HM stands for heat management) reduces heat buildup by virtue of improved thermal permeability, i.e. by reducing absorption. This solution is based on a new pigment system that absorbs visible light, while partially transmitting heat radiation (Fig. 1).

The wavelength of visible light is below 1 µm, while most thermal radiation in the headlights has a wavelength of between 2 and 15 µm. The objective was therefore to achieve the maximum possible absorption and thus a black color in the visible light range. By contrast, transmission was to be a maximum above 1 µm in order that surface warming by absorbed thermal radiation could be minimized. This is achieved with the new HM pigmentation (Fig. 2). Just how effective this black pigmentation is can be shown by a test: panels roughly 2 mm thick are heated for 2 minutes with a 20 W halogen lamp and the surface temperature is measured with an infrared thermometer about 10 s after the heat has been removed. Compared with the temperature of 190 °C reached by the classic sample pigmented with carbon black in the test, the maximum temperature of the samples pigmented with HM is 40 to 60 °C lower. Even if the plastic contains twice as much HM black pigment as carbon black, the maximum temperature is only 150 °C. The wall thickness may require increased pigmentation in order that the same blackness may be obtained. The first serial applications already exist (Fig. 3).

Fig. 3. Hella is already using Ultrason E2010 MR Black HM for its mass-produced reflectors

Flowability and Swelling Improved

Headlight applications impose the toughest requirements on surface quality. Other criteria that must be taken into account include heat resistance, along with impact strength, flowability and demolding properties, fogging tendency, and thermal expansion. The chemical structure of existing heat-resistant thermoplastics means that optimization is possible only within narrow limits: if the flowability is improved by lowering the molecular weight, impact strength and stress cracking deteriorate. The use of flow-improvement additives is often disadvantageous, since the additives tend to fog under the high temperatures in the headlights.

For this reason, BASF has taken a new approach to improving the properties, e.g. flowability, of the high-performance plastic PESU. Through targeted blending with other thermoplastics, it has created a new material that offers a range of benefits, from ease of processing through to service properties. Although the new Ultrason E 2010 MR HP (HP stands for high productivity) cannot compete with BASF's high-speed products, its flowability is 10 to 20 % superior to that of the pure PESU. Moreover, blending has significantly improved further properties, the overall effect of which is to yield a very interesting range of properties. Thus, the heat resistance of metallized parts can be kept very close to that of pure PESU while the density and water absorption are reduced. In addition, the new blend, despite its better flowability, features superior impact resistance to that of the higher-molecular PESU materials. Because the new material is a blend and is thus much less transparent, it is not suitable for transparent applications. Furthermore, the lower transparency confers a great advantage for quality control, especially where headlight production is concerned – with transparent materials, many errors are only visualized by the metallization process. Lower transparency also makes it easier to dispense with additional pigmentation (Fig. 4).

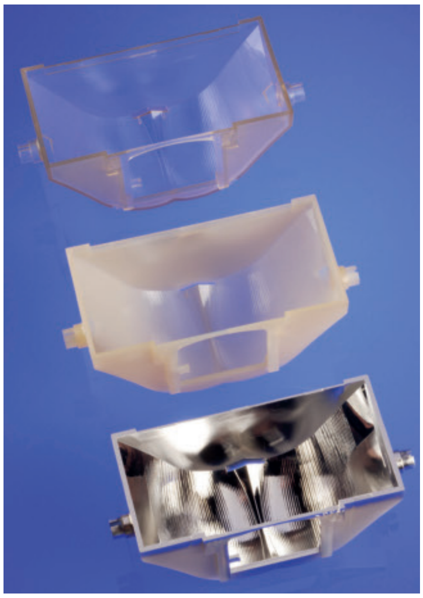

Fig. 4. The new Ultrason E 2010 MR HP, a polyethersulfone, displays a 10 to 20 % better flow behavior than pure PESU

Injection molding flaws are not only more visible in the new blend, but are al-

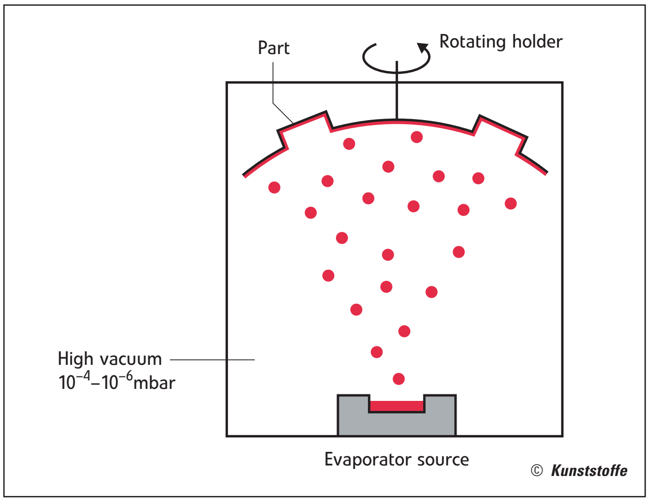

Fig. 5. Physical Vapor Deposition: The headlight is mounted on a rotating holder and aluminized under high vacuum

so easier to avoid. Heat-resistant thermoplastics typically show little or no swelling during processing. This property is responsible for the so-called record effect that occurs, for example, when the mold temperature or the injection speed is too low. The low degree of swelling often causes problems when the material negotiates sharp-edged transitions or flows over ribs. If the air is not displaced evenly from the cavity, fine flow lines form readily behind such critical points. The new material blend swells much more than pure PESU and reduces the risk of these injection molding flaws. The improved swelling behavior – as well as the improvement in the other properties – is due to the special morphology of the blend. A very fine dispersion of the two blending partners leads, for example, to optimized impact strength.

Producing High-quality Surfaces with PBT

Any inexpensive material for the production of headlight bezels should yield an excellent surface, be easy to process and metallize directly, as well as exhibiting the lowest-possible fogging. The use of PBT in this field continues to grow, because the material offers greater thermal stability and adhesion to metals compared to standard PC and better dimensional stability and reduced tendency to fogging relative to PA.

Bezel frames are relatively large automotive parts. In the past, this sometimes led to difficulties when it came to removing the bezels from the molds: semicrystalline material shrinks onto the mold during cooling, with the result that the parts are difficult to deform and may even adhere to the mold.

In the case of Ultradur B 4560, an unreinforced PBT which was developed specifically for use in bezels, shrinkage was reduced significantly compared to that of standard PBT grades. Thanks to a special modification to the material, the part can be removed more easily from the mold and automated processing runs more smoothly.

The surface texture of the material is also significantly improved by the special recipe. The part's surfaces are so flat that bezels made from Ultradur 4560 can be directly metallized to yield surfaces of extremely high quality. In PVD (physical vapor deposition; Fig. 5), the parts are moved straight from the mold into a vacuum chamber, where they are metallized with aluminum in a high vacuum. There is no need for primers to improve adhesion to the metal. Only parts that offer the best surface texture can undergo direct metallization. The reason is that the very thin aluminum layer makes surface defects such as sink marks and welds visible, as a result of which light reflection in the finished headlight suffers. PVD coating is slowly superseding the older wet chemical process in which parts are etched in chrome sulfuric acid baths and metallized electrochemically in immersion baths.

Aside from the greater ease of processing and the high surface quality of the finished parts, the new PBT offers a further advantage by virtue of its low fogging tendency: plastics in bezels tend to suffer from fogging in chronic use due to high temperatures and the gas emitted can precipitate on the PC cover of the headlight. Moreover, the surface of the bezels becomes uneven due to new defects; both these effects impair light reflection of light and the appearance of the headlights. Even at high temperatures, Ultradur 4560 exhibits significantly decreased fogging (Fig. 6).

Fogging Test

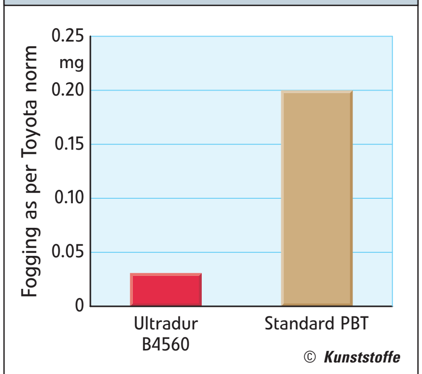

Fig. 6. Specially designed for use in bezels, the new PBT Ultradur 4560 B exhibits much less fogging at high temperatures

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Already Used in Eight Series

The new PBT material is the result of a multi-year global BASF research project that gathered and evaluated the requirements of customers from Europe, Asia and North America as regards headlight bezels and integrated them into the new material. During the project, the different variants were developed in the BASF Polymer Research and Application Technology and evaluated in direct cooperation with the customers. The new product has been on the market since early 2007 and is already employed in eight different car models. ■

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