

Lighting the way to your car

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On the new BMW 7 Series, a lighting system featuring a striped pattern of ground illumination makes it easier to enter the vehicle in the dark. Fraunhofer researchers have developed special microoptic lenses for this application to channel light from the vehicle underbody directly onto the ground, illuminating the path to the car.

You've just enjoyed dinner at your favorite restaurant and now it's dark outside. Unfortunately, the restaurant parking lot is rather poorly lit, but the driver knows what to do. With just a press of the key fob, a striped carpet of [light](#) appears on the ground illuminating the path to the car.

This design element available on the new BMW 7-series is based on special microoptics developed by the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena. "Thanks to these specially designed microoptics it's possible to project light beams from the underbody to the ground in a striped pattern covering around four square meters at the vehicle doors on both sides," says Dr. Andreas Bräuer, Microoptic Systems department head at the IOF. These guide lights are not a completely new feature, and other premium carmakers are also working on similar systems for their vehicles. To date, though, these lighting systems have been installed in either the exterior mirror or the door. This is problematic: When integrated into the mirrors, the light moves away from the path it is supposed to illuminate when the door is opened; placed at the bottom of the door, the light cannot reach the ground below until the door is opened.

The BMW Welcome Light Carpet is different. With this system, the

lighting module is installed on the body sill to the vehicle underbody under the driver's door. How then is it possible for the light to travel "around the corner" to the path leading to the door? "Our microoptics feature microlenses that aim the light directly at the desired surface," explains the IOF's Dr. Peter Schreiber, who oversees the project. Initially, the IOF scientists' goal was to create tiny yet powerful digital projectors such as those used in smartphones. In physical terms this is a contradiction, as smaller projectors produce less light. However, the IOF experts have found a solution to this problem. They make the projectors extremely small, but they put many of them together in a honeycomb array. "We can alter the intensity of the light by altering the number of microprojectors used," says Bräuer. "Regardless of whether we use 150 projectors, as with the BMW Welcome Light Carpet, or we use 3,000 of them, the thickness of the array still remains within a range that is measurable in millimeters."

Projection lenses can be arranged individually

One positive side effect of this type of array lighting proved quite significant during the development of the Welcome Light Carpet. The projection lenses that catch the light and reflect it onto another surface can be individually positioned relative to the light source. As a result, the images reflected by the individual lenses in different locations can be made to precisely overlap one another. "This means we can project a high-quality and high-intensity image even if the angles of illumination are extremely low. In its first consumer application as the BMW Welcome Light Carpet, this technology gives the BMW 7 Series a new nighttime look," says designer Marcel Sieler of BMW, who is also a member of the IOF team. For the application in the car, the IOF scientists constructed a $10 \times 10 \text{ mm}^2$ microoptic assembly that is fitted with a glass cover. To protect the sensitive device against stones thrown up while driving, the opening was positioned on the underbody facing away from the direction of travel. Meanwhile, minor smudges of dirt on

the glass cover are no problem for the specialized optics because the numerous individual projectors represent a multi-channel lighting design: Dirt may reduce the brightness under certain circumstances, but the light will never be completely blotted out.

The BMW Welcome Light Carpet is now standard equipment on the new BMW 7 Series. "This marks the first time our technology has been applied in a volume market," Bräuer adds happily. Yet the development team also has its eyes on new application areas. "There is an extremely wide range of possible uses for this type of array lighting, extending from safety technologies and medical applications to mechanical engineering and traditional signal lighting," he says.

Provided by Fraunhofer-Gesellschaft

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