Shy Technology in Displays for Automated Driving

In progressively more automated passenger cars a wide choice of information gets depicted on ever larger displays. However, not every content is always relevant. Plus, displays can be a distraction. As an alternative to large displays, which are visible in the interior, Continental has developed the restrained, tranquil and so-called shy display technology. Future displays of this type will only be visible when they are needed. At other times they have the look and feel of a high-end surface material.

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The car is changing from a means of transport to an extended living and work area. This trend is driven by higher automatic driving capabilities which offer new degrees of freedom also for drivers to decide how they wish to utilize the time spent traveling. Typical options in a connected and digitalized car include information access and communication as well as the possibility to work while on the road. Large display areas are the basic requirement for these options [1-3]. It is therefore no wonder that along with digitalization and the growing importance of vehicle software, display dimensions (diagonal) have continuously grown over the years, **FIGURE 1**. In connected and increasingly automated vehicles, a wide choice of information gets depicted on ever more and ever larger screens. However, not every content is always relevant. Plus, displays can be a distraction.

Since the early days of digital information output in the vehicle, display technology has been permanently optimized. Today, there is practically no limit for designers which has led to the first concepts from A-pillar to A-pillar

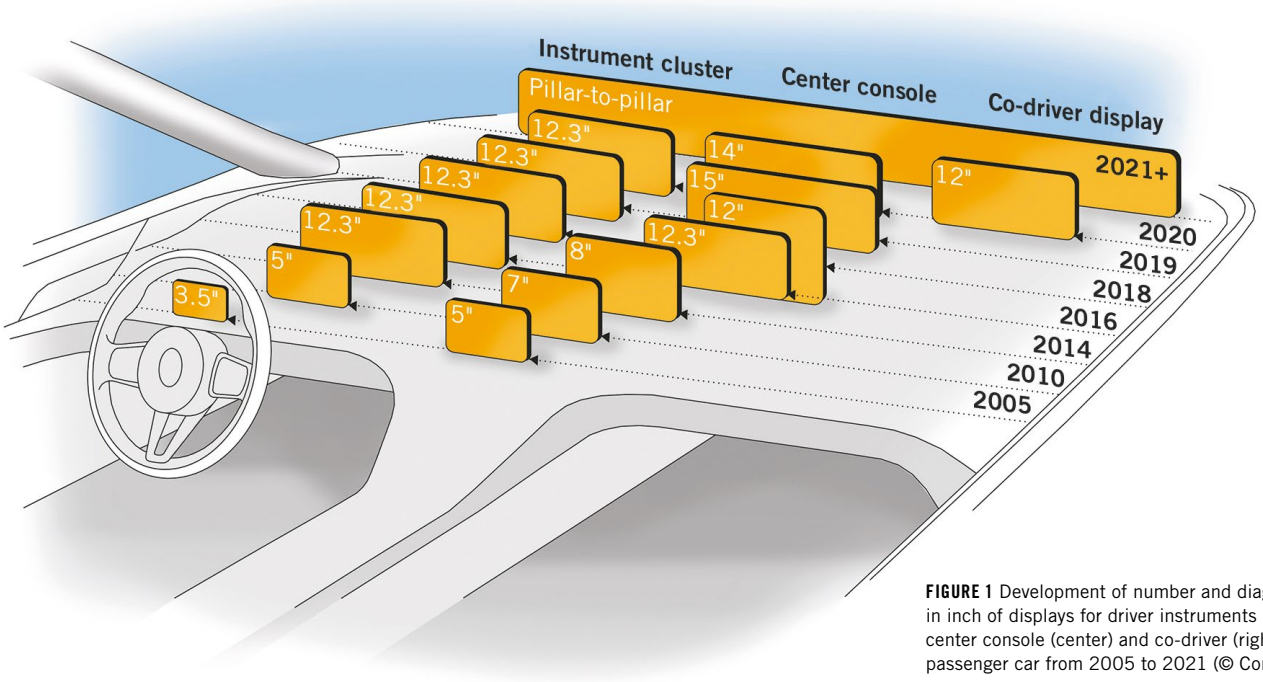


FIGURE 1 Development of number and diagonals in inch of displays for driver instruments (left), center console (center) and co-driver (right) in a passenger car from 2005 to 2021 (© Continental)

shaping the vehicle interior in a way never seen before. Increasingly, the user experience in the cockpit is influenced by the integrated displays. This is where new challenges arise: First of all, large and permanently visible displays and the wealth of information they depict can be a distraction thus impacting driving safety, unless the displays are embedded in a smart and holistic concept of human-machine interaction.

FIGURE 2 Instrument panel with fully activated shy displays (© Continental)

Secondly, displays pose a design challenge because while they are very attractive in the active state, empty display surfaces have no appeal at all. Flat displays in particular are not easily integrated into harmonious cockpit lines. This was one of the reasons why OEMs kept using classic instruments for a certain time. In the ignition-off state they retain a more high-grade look than inactive displays.

The shy display technology offers an alternative to this. Continental has used this solution as a development basis for displays which seamlessly blend into instrument panels by showing the same high-grade surface look and feel, **FIGURE 2**. In their inactive state, the currently exhibited prototypic samples show no visible display zones or display areas at all. Yet, when required, a brilliant display can be activated in each of the three typical information zones – for driver, center console and co-driver. This product was awarded the German Design Award 2022 in Gold as a pioneering, innovative technology.

SURFACE AND FUNCTION OF THE DISPLAYS

A cockpit based on the shy technology approach seamlessly integrates high

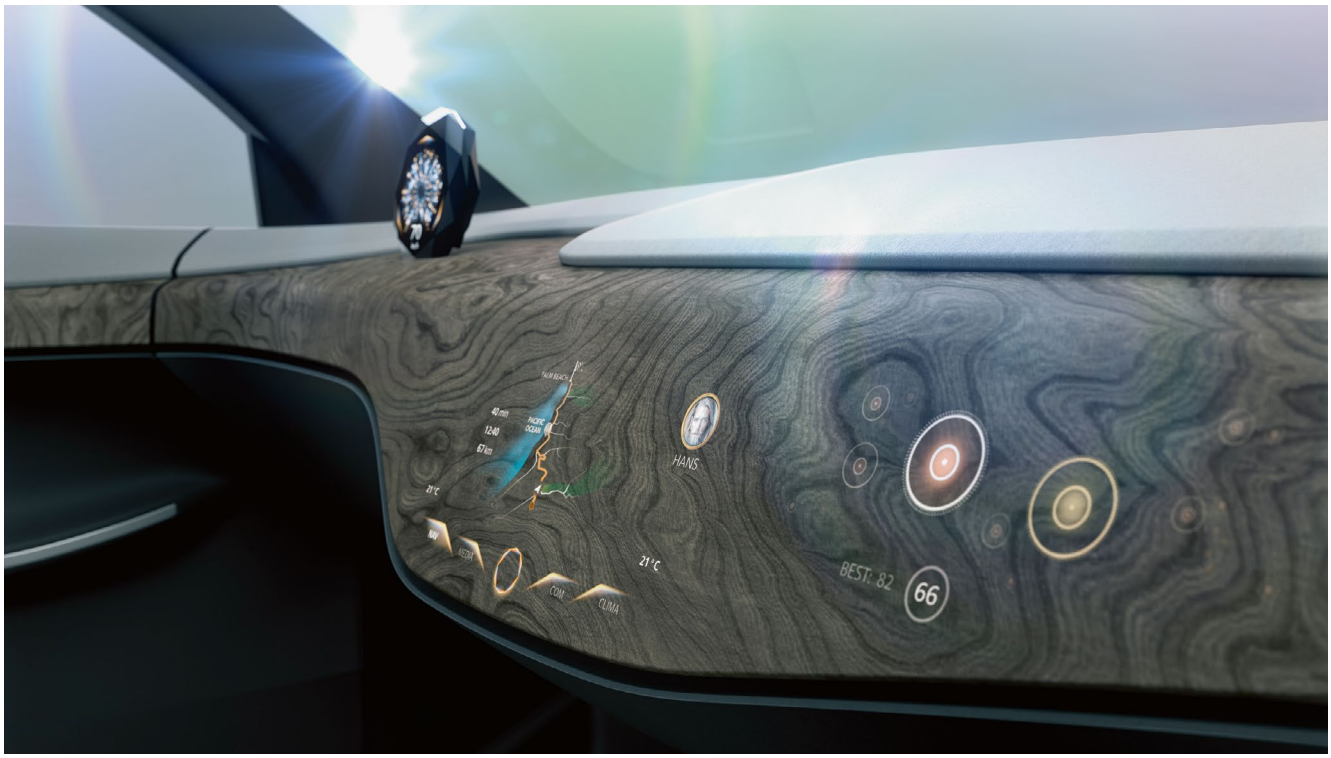


FIGURE 3 Information and control options are always there, however, they only become visible when needed (© Continental)

resolution displays into a two- or three-dimensionally curved surface with, for instance, a genuine wood, carbon, or leather appearance, **FIGURE 2**. When required, individual or all displays are activated and can thereby span the entire width of the instrument panel. The information output can be adjusted to the specific driving situation through freely choosing which display areas are activated. The driver will get exactly the amount of information needed. Driver distraction caused by a sensory overload is avoided just as easily as a lack of information. Compared to other display integration approaches, shy technology upgrades inactive display areas because they have the visual appeal of the "material" of the instrument panel instead of showing black spaces.

This is enabled by an innovative semi-transparent surface which meets many optic and haptic requirements at once. The surface material ensures that each display is seamlessly integrated into the surrounding surface. Even though the instrument panel appears to be a monolithic structure, navigation, or other communication/information plus touch control menus, for instance, are permanently there, **FIGURE 3**. Depending on the configuration, the display surface appears to be a wood lens or a leather-covered surface. A surface structure not only produces the look of the genuine material; it also gives it the feel of the real thing. By using this innovation, displays can now be integrated in places in the interior that were hitherto not available for it, such as the rear of the seats.

The special surface material enables elegantly curved cockpit lines. At the same time, the shy technology supports the trend to more sustainability because no (tropical) woods are needed any longer and no animal products such as leather are used. This material is disappearing from the original equipment more and more anyway.

DISPLAY FEATURES AND ITS DESIGN

Three state-of-the-art 12.3" LTPS LCDs with a resolution of 1920 × 720 pixels and local dimming matrix backlighting are integrated underneath the cover foil of the design prototypic sample shown in the instrument panel in this article. Local dimming with a dynamic range of more than 800 cd/m² brightness is available across the entire display surface. InCell touch control is available in the center console and co-driver areas. All contents are depicted in full color with only a minimal and unnoticeable color shift. There is no discernible postcard effect. That means, there is no visible display boundary in the transition area from backlighting to the surrounding cover foil. All graphic elements have sharp contours. In contrast to current displays with LED edge backlighting, the electricity demand of a shy display solution can be reduced along with the number of activated displays via the local dimming algorithms, **FIGURE 4**.

The surface of a shy display consists of a lens with several optical layers. This includes the semi-transparent, printed and potentially embossed cover foil, Optically Clear Adhesive Foils (OCA), plus transparent mechanic components. This cover lens is laminated onto the display underneath and its circumferential aluminum frame via OCA, **FIGURE 5**. To ensure a sufficient mechanical stiffness and good handling properties during manufacturing, a certain thick-

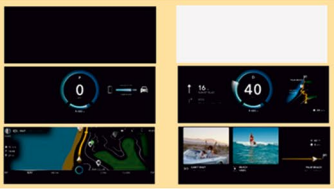
	Serial display	Shy technology prototypic sample
Display panel	12.3" / 1920 × 720 / 170 ppi / LTPS InCell touch	
Luminance	800 cd/m²	
Backlight concept	Edge backlight	Local dimming matrix backlighting
Number of LEDs	48	240
Power consumption (LED and driver) 	12 W (for any content)	0 to 32 W
	12 W	**8 to 12 W**
	12 W	16 to 18 W

FIGURE 4 Technical characteristics: The on-demand principle of shy displays with local dimming can lower the electricity demand compared to serial solutions as they are used today (© Continental)

ness of the lens between the cover foil and the display is required. Nonetheless, a good balance between the necessary lens thickness and the optical quality, such as the image focus, is achieved. For the mass-manufacturing of this kind of optical stack, highly refined process technologies including principles like injection molding as In-mold Labeling (IML) or In-mold Decoration (IMD) are available.

RESULTS OF OPTICAL QUALITY MEASUREMENT

The exemplary surface design chosen for the prototypic sample shown here is based on a development and print specification created by Continental and its engineering partners. The goal was a good balance between color saturation at the surface at natural ambient lighting conditions and the best possible transparency that still hides the structural elements underneath. A transmittance of around 30 % was achieved along with a low diffuse reflection and excellent daylight readability, a realistic matte surface quality closely resembling natural materials and yet only a minimal color shift of the display contents.

FIGURE 6 shows the transmittance spectrum that was achieved with one of two investigated cover foil technologies for different surface designs. The cover foil used in the prototypic samples has a particularly flat transmittance spectrum which ensures a very high visual fidelity of the targeted color spectrum of all display contents. In principle, every foil layer does exert a potential effect on the image quality because the foil causes a certain scattering and soft-focus effect. To assess the image quality of the shy display against an objective scale, Continental has utilized the contrast (C) measurement with the Modulation Transfer Function (MTF).

For single pixel lines (black/white), a CMTF of 0.5 is considered as the lowest limit for text information readability, and a CMTF of 0.25 is considered as the limit for video content. Different foil technologies were explored and measured, which led to selecting a foil technology: The cover foil used in the prototypic samples achieves a CMTF of around 0.8 which is an excellent result in the prevailing view.

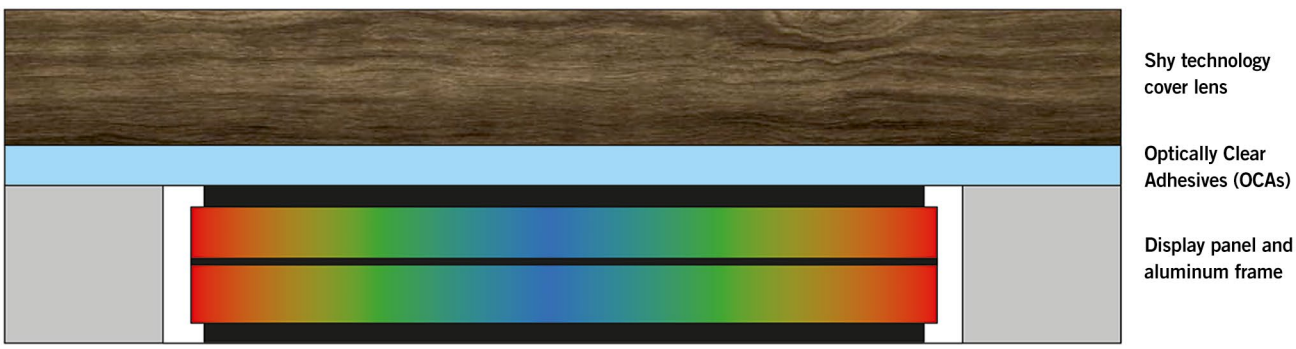


FIGURE 5 Multilayer structure of a shy display solution (© Continental)

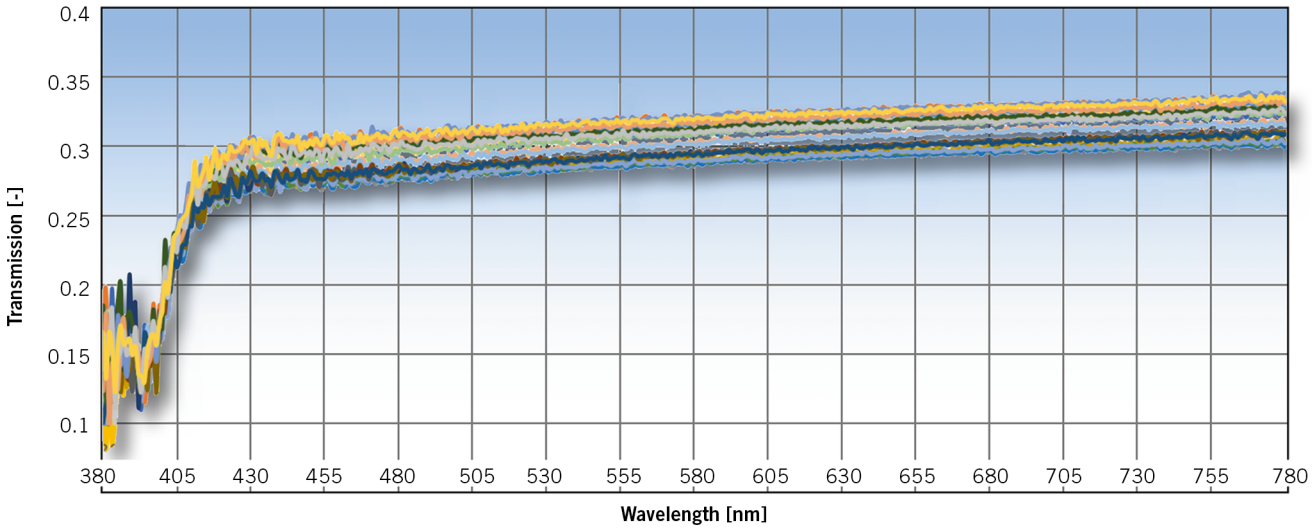


FIGURE 6 Transmittance characteristics of the chosen foil technology across the color spectrum (© Continental)

SUMMARY AND OUTLOOK

While large displays areas are the future of the vehicle cockpit, they present a risk of sensory overload – at least in some situations. Display contents can distract the driver which can impact driving safety. Also, conventional displays make it difficult to design instrument panels with harmoniously curved lines. This is a particularly tricky point whenever displays are not activated and turn into black surfaces without visual appeal.

The so-called Shy technology, in contrast, makes it possible to seamlessly integrate information and control options in a three-dimensional, therefore free-form instrument panel. The combination of a fine-looking surface, curved areas and a permanently available, yet unobtrusive presentation and control option generates an attractive user experience. Shy displays not only support a harmonious cockpit design, they also increase user friendliness and driving safety. Potential distractions are literally hidden and information and functions are offered on demand. Display areas can even be integrated in places in the interior that were previously inaccessible for this purpose.

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