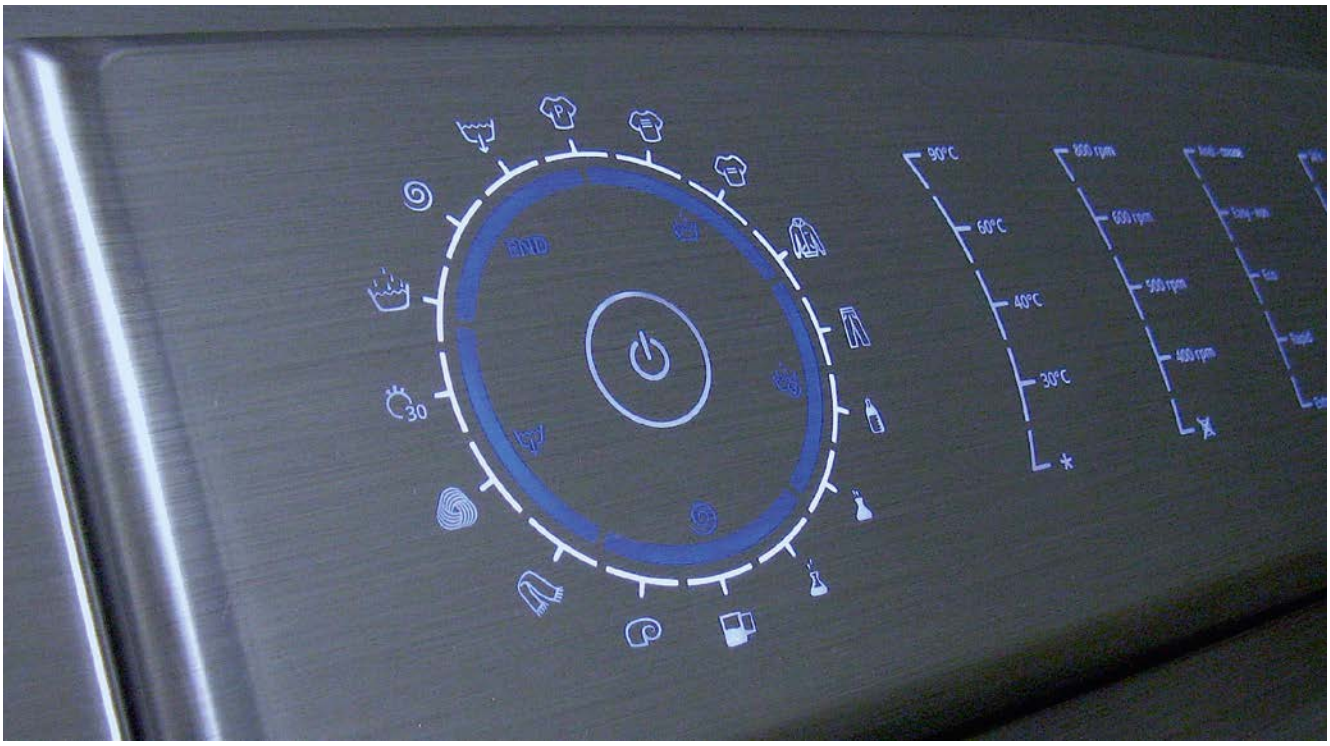
Three-Dimensional Control Panels with Film Technology

Great Cost Reduction Potential for Operator Terminals and for the Further Development of Device Designs

The touchskin user interfaces of the Austrian technology developer plastic electronic have reached the third dimension. They open up entirely new possibilities for a more organic device design that increasingly eliminates the boundaries between form and function. For this purpose, a functional composite film is assembled and formed at comparatively low overall costs.



The current stage of development of Multiskin composite films allows the production of three-dimensionally shaped user interfaces, for example with profile areas for finger guidance (© plastic electronic)

Providing films with functional structures and using them to develop 'sensitive' device surfaces is the common thread that runs through our ten-year company history," says Philipp Weissel, managing partner of plastic electronic GmbH from Linz, Austria, summarizing the company profile. The functionality of the current, second-generation component-integrated sensor surfaces with the product name "touchskin" is based on a so-called Multiskin composite film.

The multilayer-bonded composite film behind such a touch-sensitive device surface, and whose individual layers (each with a specific coating) are responsible for the diverse functions, includes:

- the sensor surfaces, along with the electrical conductor paths to the control circuit boards,
- an LED lighting system,
- the graphical user layout and
- the surface decor.

All elements are incorporated within a stable composite panel with a thickness of only 2.5 to 3 mm (**Fig. 1**). These composite components can either be integrated into injection molded parts over a small area or used as extensive housing components over a large area. »

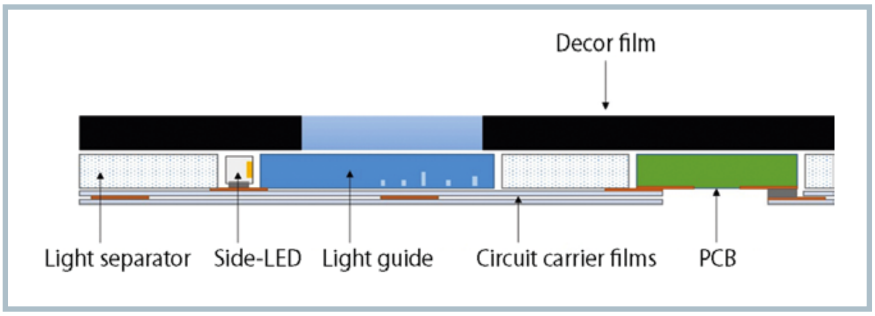


Fig. 1. Multiskin composite film components are multilayer films compounds that are laminated to stable components. The 2.5 to 3 mm composite film consists (from top to bottom) of the decor sheet (user interface), the central film with the LED lighting system, and the circuit boards, as well as the circuit carrier film (© plastic electronic)

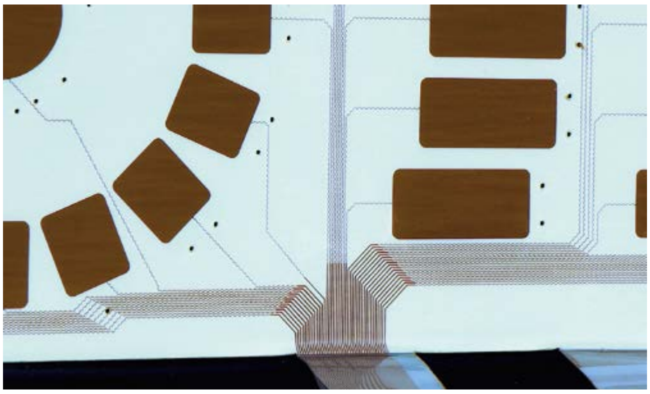


Fig. 2. A conductor path design with a meandering or "wool thread structure" makes it possible to compensate for changes in length during the deep drawing process for 3-D deformation (© R. Bauer)

The Many Features of the Composite Film

An essential part of the composite film is the circuit carrier film. It is the medium for the control signals to the electronic device control as well as the power supply for the electronic components. It must be thin, flexible, three-dimensionally deformable, and suitable for the process of mounting electronic components. Polyester films meet these criteria. If there is no component mounting, e.g. for touch sensors, then PET films can be used. PEN films (polyethylene naphthalate) are preferable when production, particularly the assembly process, involves higher temperature exposure.

The conductor paths must also have the required properties and, moreover, tolerate the stretching resulting from the deformation without losing their conductivity. The coating process for the conductor paths uses either a printing process with silver paste or vapor deposition or lamination of copper layers. However, the former is only used if the conductive structure is not too large and complex.

Special production methods or designs are available to make the copper conductor paths stretchable and deformable. For example, a conductor path in a meandering shape can be stretched within ample limits without tearing. Vapor deposition processes enable the application of thin copper layers (less than 1 µm) that are also very stretchable (more than 70 %) and inexpensive to manufacture (**Fig. 2**). However, due to their low layer thickness and thus their low current carrying capacity, the latter is only suitable for transmitting touch sensor signals. Conductor paths made from 18 µm electrolytic copper are used to supply the LEDs with power. For this purpose, a copper film is laminated locally onto the carrier film and then structured with a conventional etching process (**Fig. 3**).

The electronic components are bonded to the conductor paths on the film by either low-temperature soldering or by gluing with conductive adhesive pastes. The smaller the components and their contact distance are, the more preferable low temperature soldering becomes.

What Can the Sensitive User Interface Do?

Touchskin user interfaces are seamless surfaces with a uniform appearance. Materials such as plastics, wood, or glass are suitable for this. It should be noted that

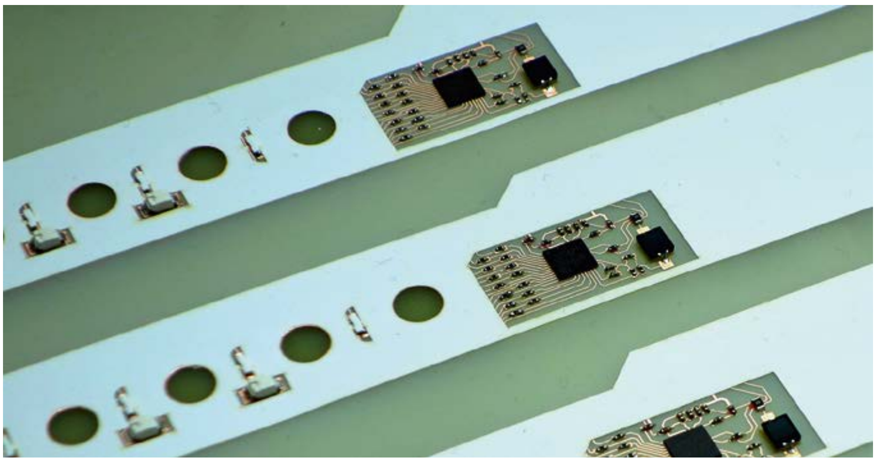


Fig. 3. For conductive structures that carry higher currents, copper layers that are patterned by etching process are laminated on (© R. Bauer)

this surface must have no or only very low conductivity. Conductive surfaces (e.g. made of metal) would act as a shielding layer and make touch operation impossible.

A printing process is used to design the film layer of the operator interface, and in such a way that the layer is translucent where the light-emitting elements are located and the printing also determines the color, density, and uniformity of light emission. The translucent areas can be designed so that they are recognizable only with activated lighting (vanishing effect). For user interfaces that do not require light-emitting elements, the surfaces can also consist entirely of non-transparent materials.

Transparent film materials such as PMMA, PC or PET are generally used for this purpose, and are printed either on the back or on the front by means of screen printing and other printing processes. According to requirements, the surface is additionally coated with a transparent conformal coating (e.g., hard coat) or a transparent plastic (e.g. a thermoplastic or PU). This increases the resistance of the surface to external influences (mechanical or chemical resistance, anti-fingerprint). Matt and glossy to high-gloss surfaces can be produced with the process.

From Local Control Panel to Large-Area Device Skin – Anything Is Possible

Touchskin technology opens up the possibility of integrating switch or slider functions directly into a plastic component in a seamless touch finish or combining them with other surfaces (such as glass or wood) by back bonding. Advantages of this method are functional integration in a confined space and a significant reduction in the number of system components and thus assembly costs. Small- to medium-sized Multiskin composite parts can be directly incorporated into plastic housing as local operator islands by means of in-molding. Application examples are the keypads of device remote controls (**Fig. 4**) or user interfaces on door trims and car steering wheels. The size limit for these applications is set by the molding shrinkage of the molded part and the force acting on the composite part or the technical possibilities for decoupling this effect.

Fig. 4. One way to reduce the shrinkage effects on the composite film is by in-molding with a frame structure, which also acts as a carrier for the mechanical interfaces to the partner components; shown here with the example of a 2.2 mm laminated composite panel with integrated lighting system and 12-pin connector (© Schöfer GmbH)

Large components, such as control panels for washing machines or dishwashers, can no longer be in-molded without being deformed by the distortion effect. It is thus recommended to produce the composite film and the injection molding structure separately as the size increases, and to use a mounting process to fix it onto the device, e.g. by bonding with a support structure.

Large-Area Operator Terminals for Innovative Device Designs

Plastic electronic demonstrated the potential of this technology by means of a washing machine display with 40 backlit operating buttons and a new, self-explanatory operating logic. Regarding this, Philipp Weissel says: "The biggest evolutionary step in our user interfaces is the successful integration of a deformable LED lighting system." This is because the necessary wall thickness of the central "light film" of around 1.5 mm means the composite film has mutated into a stable sandwich panel (**Fig. 5**). "The targeted tuning of all film and coating properties within the composite allowed us to achieve extensive deformability of the sandwich panel. The user interface can now become a part of the device skin," says Weissel.

According to the current state of development, the deformation of the composite film has the following restrictions (**Fig. 6**):

- Film areas without lighting and control elements can be stretched up to 100 mm in height with a minimum bend radius of 2 mm (A).
- Height stretching of up to 40 mm with a minimum bend radius of 2 mm is »

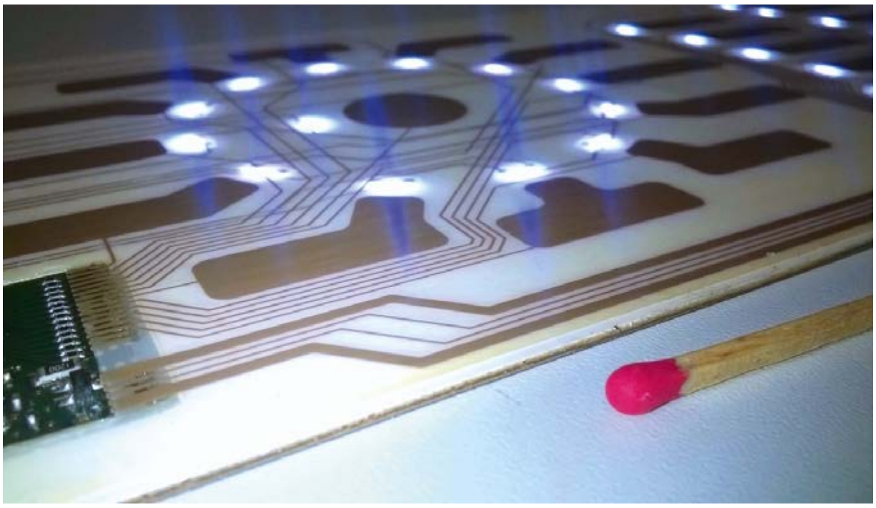


Fig. 5. Detailed view of the composite film: The central light film has areas that are illuminated by one light-emitting diode with lateral light emission. The light film is covered with a film on which the conductive structures for controlling the sensor functions are located (© plastic electronic)

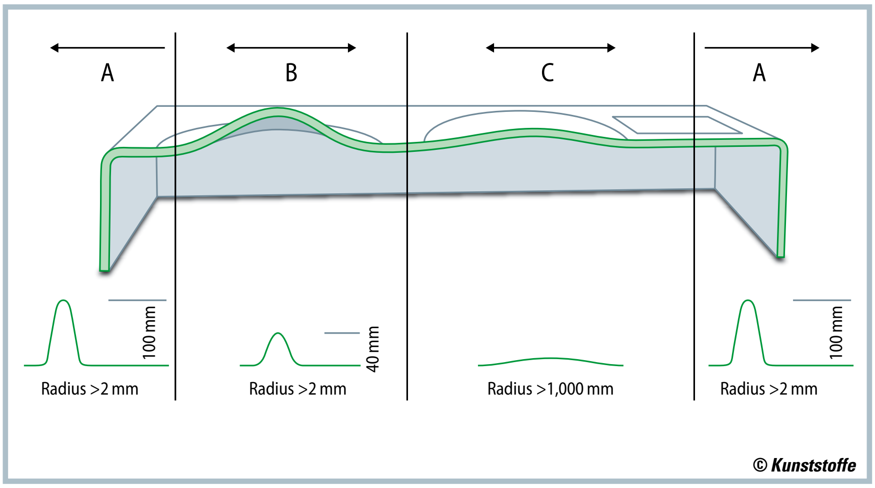


Fig. 6. Design guideline for touchskin user interfaces based on the currently feasible stretching ratios (source: plastic electronic)

possible around control elements (without light-emitting elements) (B).
- Curvatures with a radius of 1,000 mm and greater are possible around light-emitting elements (C).

Philipp Weissel adds: "Our latest development success greatly expands the boundaries for device design, which is increasingly focused on organic shapes with rounded and curved surfaces. Conventional flat touchscreens or flat key terminals look increasingly out of place here. Our alternative is three-dimensionally-shaped housing surfaces with the functional integration we've developed." In terms of the operation of household appliances (white goods), this makes not only the precise adaptation of the user interface into the device design possible, but also the integration of geometric structures for finger guidance (grooves, waves, ring grooves; see **Title figure**).

Another advantage of the composite films is the flexibility in manufacturing the composite parts. Language, color and pattern variations can be implemented easily and quickly, even for small batches, by exchanging the decor film. Once again, CEO Weissel: "Our position as an independent technology company puts us in the position to help all device manufacturers shorten development phases with a design guide as well as prototype development." ■

Company Profile

Founded in 2006, **plastic electronic GmbH** is a "spin-off" of the Johannes Kepler University in Linz, Austria. The initiative for the founding of the company came in 2005 from Univ. Prof. Dr. Serdar Sariciftci, who had conducted research on electrically conductive plastic structures for many years with Nobel Prize winner Alan J. Heeger at the University of California, Santa Barbara, CA/USA, and then established the Institute for Organic Solar Cells at the Johannes Kepler University in Linz. Alongside the research projects in the field of polymer electronics, the current focus is on touchskin projects.

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