Composite Films Integrate Lighting and Control Sensors in Decorative Surfaces

The "touchskin" Technique of plastic electronic Has Outgrown the Experimental Stage

The first production-ready sensor panel for complex control functions is a composite film component with 40 sensors operating in six groups. The built-in lighting system can be activated together with the sensor functions locally at each operating point. The structurally stable composite film that consists of three functional levels can be installed directly in the terminal or embedded with a newly developed injection molding application in a housing part either.

The control panel for washing machines is a multi-layer composite film in "black-panel design" with 40 backlit control sensors. It offers great ease of use for the user and high savings of production and assembly costs (figure: R. Bauer)

With the first presentation of a functioning operating terminal without buttons at the K 2010, the plastic electronic GmbH, Linz, Austria, succeeded to prove that on/off switch, rotary or sliding potentiometers can be integrated directly into structural components, i. e., without additional add-on pieces. This technology works with a combination of carrier films, which are prepared by vacuum deposition with metallic conductor path structures, and a protective or adhesive film that establish contact with plastic melt.

This premiere at the booth of the injection molding machine manufacturer Engel Austria GmbH, Schwertberg, Austria, was the dawn of the so-called "touchskin" technique. The integration of functions is effected by the back-injection of two films, specifically in the form of a sandwich component with two film surfaces (sensor film and decorative sheet), separated by an injection molded plastic core layer (**Fig. 1**). In addition to the verification of the sensor function, the 3-dimensional deformation of the circuit carrier film could be demonstrated, however, with relatively low stretching ratios.

In the next developing step plastic electronic focused on increasing the 3-dimensional deformability of the films and the conductor paths thereon. The result was shown at the Fakuma 2011 as the "Sensitive Surface" concept in terms of an automotive center console with integrated sensor multifunction operation developed for Magna group (**Fig. 2**). Despite the progressiveness and functionality the breakthrough to mass application was still not achieved, because it lacked the backlighting of the sen- »

Fig. 1. The first "touchskin" demonstration object from 2010. The elementary functional unit is a back-molded film on the inner surface of the lid with printed-on electronic structures. The outer décor film includes the function-indications. Immersions in the cover function as finger guidance (figure: plastic electronic)

Fig. 2. The result of the next evolutionary stage in 2011, demonstrated by a car center console with a central sensor area for controlling the infotainment functions. The component has an increased 3-dimensional deformation of the still back-molded functional films (figure: plastic electronic)

Composite Film of Three Functional Levels

Four years after the first presentation of functioning film-based prototypes of sensor control elements at the K 2010, the Upper Austrian technology company plastic electronic introduces the first production-ready sensor panel for complex control functions at their customer event, the "touchskin" technology day, on September 23rd 2014. It is a laminated plastic composite film part with 40 control sensors in six functional groups.
The most important innovation was the first integrated lighting system that can be activated together with the sensor function locally at each operating point. Overall, the composite film consists of three functional levels (user interface = decorative film, layer with integrated lighting system, sensor layer) which are constructed from one or more films in each case. The structurally stable film composite can be either installed directly in the terminal or embedded in a housing part using a newly developed injection molding application. Thus, all the conditions for a broad serial application are now in place.

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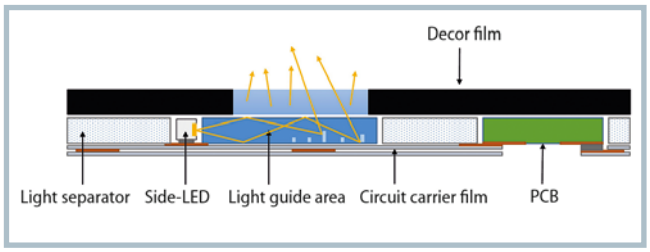

Fig. 3. "multiskin" components are multi-layer compound films, which are laminated into stable components. The composite film contains (from top down) the cover sheet (user interface), the central film with the LED lighting system and the PCBs, as well as the films with the electrical circuits (figure: plastic electronic)

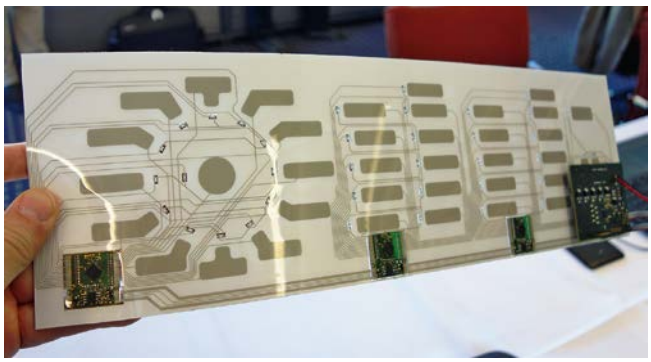

Fig. 4. Detailed view of the circuit board carrier film with the mounted control boards and the conducting paths to control the LEDs and the control sensor areas (figure: R. Bauer)

sor zones, which is an indispensable feature for the application in the dark. The development of an appropriate lighting system, whose height is compatible with a composite film, was the focus of the evolutionary stage three.

Rather Plate than Film

The integration of a backlighting system entirely changed the course of the touchskin technology. The light control system could not be integrated in an additional thin film layer as in the previous stages, as the LED lighting elements and the light guide plates require an layer with a minimum thickness of 1 to 1.5 mm. Therefore, the term "film" is somewhat imprecise in this context. In fact it is rather a "plate". In this project it is the same for the outer decorative surface, which is also the actual user interface.

Since the installation situation for big home appliances requires flat surface parts with high structural stability, the layer thickness of the décor film was increased to 1 mm, especially since a high-quality "black-panel effect" can then be achieved at the control surface. At this point it should be mentioned, that similar décor effects can be realized with thinner layers as well.

Application Example Washing Machine Control Panel

Because of this the new concept "multiskin" laminate takes place of the touchskin film concept (**Fig. 3**). CEO of plastic electronic, Philipp Weissel, explains: multiskin represents our solution for our sheet-composites made with functional surfaces and high variability. After all, the concrete coating layout can be freely var-

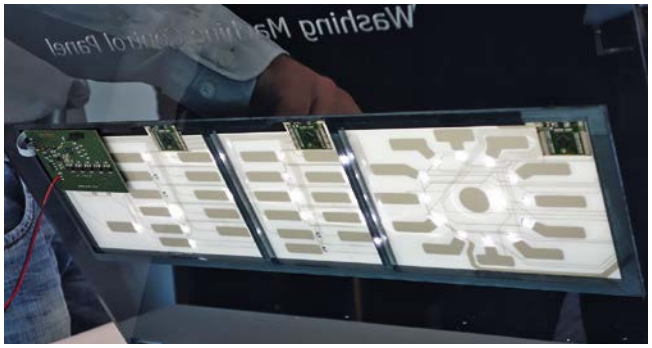

Fig. 5. Back view of the multiskin control panel in operating. The integrated LED lighting system is clearly visible. The light guide areas are each illuminated by light-emitting diodes with lateral light-emission apertures (figure: R. Bauer)

Fig. 6. Evolution step three is the rejection of the inherently stable film composites' full back injection molding. The alternative is molding only frame structures that are at the same time the mechanical interfaces to partner parts. This example shows a 2.2 mm thick multiskin composite panel with an integrated lighting system and a 12 pin plug connection (figure: R. Bauer)

ied within predetermined design rules. Thus prepared composite parts ensure not only creative possibilities for product and operating design, but also offer an enormous cost saving potential. This results from the possibility to reduce the number of single components and the associated assembly operations and, not least, from the flexible color or decor individualization even for the production of small batches."

plastic electronic developed a control panel like it is used for washing machines, dryers or dishwashers to prove multiskin's practical suitability. More precisely it is a control panel with 40 backlit control buttons. The development was not exclusively focused on solving the technical issues only, but included from the beginning practicality issues of the operating concept and its acceptance by potential users.

For this purpose, an extensive customer survey was carried out in parallel with the technological project. Its result was the guideline for the optimization of the operating logic. Now »

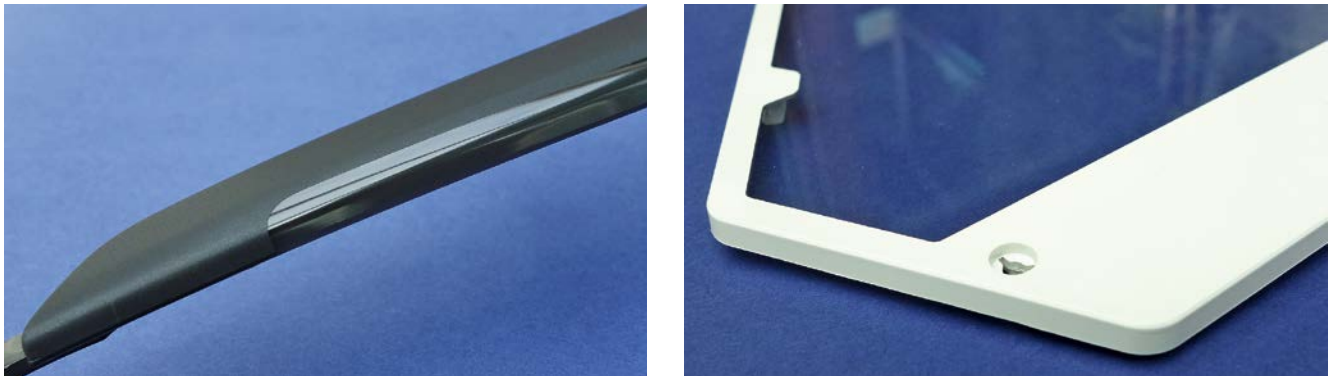

Fig. 7. Procedural in-mold assembly innovations allow absolutely seamless transitions from film surfaces to the plastics structures, even with variable insert thickness. The left figure shows the combination of a matte black décor film and a glossy molding surface, the right figure shows the seamless, gap-free embedding of a hard-coated clear-screen made of PC (figures: R. Bauer)

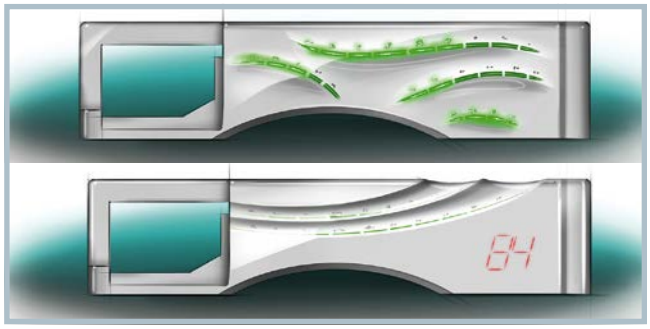

Fig. 8. The next evolutions are three-dimensional shaped control surfaces with profiled finger guides. Examples are the intuitive drop- or wave-design (concept studies: plastic electronic)

it includes six sequentially arranged sensor groups (program selection, speed and temperature pre-selection, two option groups and the timer) that were combined to four electronic functional circuits, each triggered by their own PCB (Printed Circuit Board).

The PCBs are mounted as SMD components directly on the circuit carrier film (= PET or PEN film), which is the undermost layer of the composite (**Fig. 3**). Above is the central lighting system plate made of opaque PET or PC, in which the notches for the LEDs and the light guide areas as well as the excesses for the PCBs on the neighboring circuit carrier films are punched (**Fig. 4**). The top layer is the decorative or user interface. In this project it is a 1 mm thick PMMA plate and on the back there is a black screen printing area.

On the surface the sensor labels are visible. The activated light source makes the according button position appear richer in contrast whereas not lighted positions stay almost invisible behind the black coating, the so-called black-panel effect (**Title figure**). During the production process all films are joined after the single manufacture and then laminated to a plate. Its high structure stability makes it a pre-finished part (**Fig. 5**).

Injection Molding only for Assembly Interfaces

While in the first stages of development touchskin components consistently received their stability through the back molding of films, multiskin components have such an inherent stability that adding an injection molding structure is no longer mandatory. Such laminates can be directly installed, e. g., applied and fixated in housing recesses. For installation situations in which a direct installation of the composite plate is not possible, the Austrian tool-manufacturing and injection molding company Schoefer GmbH, Schwertberg, Austria, has developed an assembly technology by which the multiskin parts can be integrated into the frame or housing structures by using the injection molding process.

Gerald Schoefer, the CEO of Schoefer, explains: "We use the inherent stability of the composite parts that do not require a lengthy stabilization by injection molding. But we add supporting frames and assembly points to the laminate panels with injection molding. Therefore Schoefer handle the laminates as inserts for the injection molding tool, stretch them as gently as possible and then embed them in an injection molding structure (**Fig. 6**).

"These structures may be necessary supports for particularly large multiskin plates by back-molded ribs and webs via mechanical interfaces to the counterpart. When embedding composite plates, seamless and smooth transition qualities between inserts and injection molding area can be reached by applying the experiences of film-insert injection-molding technique." Potential differences in the surface appearance can be minimized, like already realized serial projects demonstrate (**Fig. 7**).

Outlook

Since the K 2010 plastic electronic has developed their by numerous patent applications protected touchskin and multiskin technologies step by step on their own. CEO Philipp Weissel states: "With the washing machine panel we achieved positive test results and decent feedback from potential customers. The way to series production is therefore paved. This was our goal. Now we focus on the monitoring of specific volume applications, for which we can stand as an independent company without restrictions."

Referring to the washing machine panel plastic electronic works on the integration of geometric structures of finger guidance, e. g., rills, waves, gutters (**Fig. 8**). Weissel explains: "Parallel to accompanying the series introduction of the 2-D touchskin user-surfaces we are focusing our development efforts on 3-D designs." ■