The control panel for washing machines developed by the Austrian company "plastic electronic" is a multiskin®-multilayer-film-composite 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.

The touchskin®-technology has come of age

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 foil composite 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 film composite consists of three functional levels (= user interface = decorative film, layer with integrated lighting system, sensor layer) which are each constructed from one or more films. 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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By launching a functioning, keyless control terminal at K-2010 as technology exhibit on the booth of the injection molding machine manufacturer Engel the Austrian technology developer “plastic electronic” / Linz proved that on/off switches, rotary or sliding potentiometers can be integrated directly into structural components by the means of functional films (= carrier film with interconnect structures, which are prepared by vacuum deposition of metal coatings in combination with a protective or adhesive film for plastic melt), which means without additional add-on pieces. This was the premiere of touchskin® technology. The function of integration is effected by the back-injection two films, specifically in the form of a sandwich component with two foil surfaces (sensor film and decorative sheet) separated by a core layer made of plastic. (Fig.1) In addition to the actual function 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 interconnects thereon. The result was shown at the FAKUMA 2011 as the “Sensitive Surface Concept”, which is an automotive center console with integrated sensor multifunction operation developed for Magna. (Fig. 2) Despite the progressiveness and functionality the breakthrough to mass application was still not achieved. Because it lacked the backlighting of the sensor zones, an indispensable feature for the application in the dark. The development of an appropriate light system with an overall height that is compatible with a plastic film composite, was the focus of the evolutionary stage three.

The solution is multiiskin®

The integration of a backlighting system entirely changed the course the touch Skin® technology. The light control system could not be integrated an additional thin foil layer as in the previous stages, as the LED lighting elements and the light guide plates require a layer with a minimum thickness of 1 to 1.5 mm. Therefore, the term "film" is rather imprecise in this context. In this project this also applies to the outer décor surface, which is at the same time 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. (Fig. 3) At this point it should be mentioned,
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that similar décor effects can be realized with thinner layers as well. Because of this new concept the multiskin® laminate takes the place of the touchskin® film concept. CEO of plastic electronic, Philipp Weisel: multiskin® represents our solution for our sheet-composites made with functional surfaces and high variability. After all, the concrete coating layout can be freely varied 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.

Application example "washing machine control panel"

plastic electronic developed a control panel like it is used for washing machines, dryers or dishwashers to prove the 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 technological project. Its result was the guideline for the optimization of the operating logic. 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) for the circuit layout.

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. (see Figure 3) Above there 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 and 5). 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, which is also called the “black-panel-effect”. (Fig. 6) During the production process all films are joint after the single
manufacture and then laminated to a plate. Its high structure stability makes it a pre-finished part (Fig. 7)

**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, touchskin® components have such an inherent stability that adding an injection molding structure is no longer mandatory. touchskin® 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 / Schwertberg / Upper 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. These CEO Gerald Schoefer: "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 we handle the laminates as inserts for the injection molding tool, stretch them as gently as possible and then we embed them in an injection molding structure. (Fig. 8a+b)

These structures may be necessary supports for particularly large multiskin®-plates by back-molded ribs and webs via mechanical interfaces to the counterpart, if necessary. Derived from the experiences with film-back-molding-technique when embedding plastic films seamless in plastic structures, also composite plates can be embedded seamless as well. Potential differences in the surface appearance can be minimized, as demonstrated already realized production projects in film molding." (Fig. 9a+b)

**Summary and Outlook**

plastic electronic CEO summarizes: "In accordance with our self-conception as technology developing company we have developing our, by numerous patent applications protected touchskin®- and multiskin®-technologies on our own initiative since the K-2010. With the washing machine panel we achieved positive test results and decent feedback from potential
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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." The above report is an intermediary statement on the way to future development activities. Plastic electronic-CEO Philipp Weissel: “Parallel to accompanying the series introduction of the 2D touchskin®-user-surfaces we are focusing our development efforts on 3D designs. Referring to the washing machine panel this means the integration of geometric structures of finger guidance (rills, waves, gutters).” (Fig. 10a+b)

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about „plastic electronic“
plastic electronic was founded as a „spin-off“ of the Johannes Kepler University in Linz in 2006 on the initiative of Univ. Prof. Dr. Serdar Sariciftci who studied electrically conductive plastics structures together with Nobelist Alan J. Heeger at the University of California, Santa Barbara and then established the Institute of Organic Solar Cells at the Johannes Kepler University in Linz. In parallel to the research project in the fields of polymers electronics the current focus is on touchskin® projects. More at: www.plastic-electronic.com

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Fig.1: First touchskin demonstration object integrating on/off-buttons as well as sliding and rotary potentiometers 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.

Fig.2: The result of the evolutionary stage 2 of the year 2011 was the increase the 3-dimensional deformation of the still back-molded functional films, demonstrated by a car center console with a central sensor area for controlling the infotainment functions.
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**Fig. 3:** *multiskin* components are multilayer films compounds, which are laminated into stable components. The film composite consists (from top down) from 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.

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**Fig. 4:** Detail view of the central light film resp. light plate with the inserted light guide areas, which are illuminated by light-emitting diodes with lateral light-emission apertures.
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Fig. 5: 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.

Fig. 6: Detailed view of the user interface of a 1 mm thick PMMA-film, which was coated in black by back all-over screen printing, which allows a “black-panel” effect and is additionally protected by a “hard-coat-finish”.

Photo: Author
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Fig. 7: Back view of the **multiskin** control panel in operating. The integrated LED lighting system is clearly visible.

Fig. 8a+b: Another evolution step 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 thick **multiskin** composite panel with an integrated lighting system and a 12 pin plug connection.
Fig. 9a+b: Procedural in-mold assembly innovations by Messrs. Schoefer GmbH allow absolutely seamless transitions from film surfaces to the plastics structures, even with variable insert thickness. Fig. 9a shows the combination of a matte black décor film and glossy molding surface, Fig. 9b shows the seamless, gap-free embedding hard-coated clear-screen made of PC.

Fig. 10a+b: The next evolutions are three-dimensional shaped control surfaces with profiled finger guides. Examples are the intuitive drop- or wave-design.