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HANSER

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Positionally Accurate Decoration and Backlighting

3-D Capacitive Sensors

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Positionally Accurate Decoration and Backlighting

3-D Capacitive Sensors. A glimpse into the car interior of tomorrow? The MyWave-3D development project presents touch-sensitive operation by means of capacitive fields on a convex, IML-decorated and backlit surface. This is made possible by means of a novel circuit board conforming to the part geometry and populated in 3-D.

At the core of the MyWave-3D is the combination of a curved injection molded part that is decorated by in-mold labeling (IML), and a 3-D circuit board conforming to the part contour (photos: KH)

SABINE KOB

How do we imagine that radios, air conditioning or hands-free phones in car interiors will be operated in future? Will there still be a plethora of buttons press, or will touch-sensitive operating concepts prevail here, as with smartphones or tablet PCs? If the design departments of large automotive companies are to be believed, the latter will be the case – and industry is being asked to create the technical prerequisites for this.

The joint development project MyWave-3D by Kunststoff Helmbrechts AG (KH), Helmbrechts, Germany, and MID-Tronic Wiesauplast GmbH, Wiesau, Germany, is now completing an important technology step and permitting touch-sensitive operation by means of capacitive fields on a three-dimensionally shaped, decorated and backlit surface.

At the core is the combination of a curved injection molded part that is decorated by in-mold labeling (IML), and a 3-D circuit board conforming to the part contour, which is populated with electronic parts by a newly developed 3-D automatic SMT placement unit. The new concept thus meets considerable demands, which users are familiar with from car interior design – high-quality surfaces with printed operating symbols and backlighting, permitting a day and night effect.

Printing Process Must Allow for the Subsequent Deformation

The surface technology was the responsibility of KH, with its IML-specialized subsidiary Foliotec GmbH, Sparneck, Germany, which produces the operating element in three versions: with high-gloss black and scratchproof coated, matt-black or transparent surface. For the black variants, a 250 µm-thick PC film is multi-pass printed **(Fig. 1)**: two times black, in which the first pass precisely defines the outlines of text and symbols, and the second is opaque to deepen the black and prevent so-called "flashes," i. e. gaps in the printed area.

The black layers have a double white backing to make the symbols visible. To achieve a black-panel or disappearance effect in the upper region of the part, two black translucent layers are printed – then the IML film is coated overall with clear lacquer. In the positioning of the symbols, the subsequent deformation (18 mm convex, edge radius 1 mm) must be taken into account so that afterwards everything is in the right place. After forming of the heated film with over 100 bar compressed air, the scratchproof coating of

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the black high-gloss MyWave version is cured under UV light. Following stamping and insertion into the mold, the film blank is backmolded with PC.

LDS of the Circuit Board

The novel 3-D circuit board with the electronic components comes from the partner MID-Tronic. It is provided with conductor tracks, capacitive surface and shielding by LDS (laser direct structuring) **(Fig. 2)**. The circuit board is produced from a polymer, which contains additives and is activated by laser at precisely defined points. The bond between the polymer and additives ruptures here, and the above-mentioned conductive tracks and surfaces are produced from the now-exposed copper ions, in a multistage process.

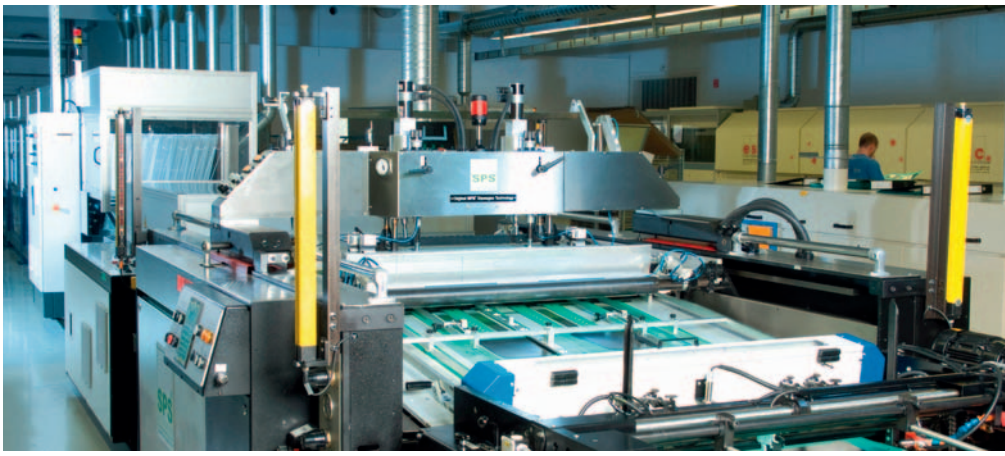

Fig. 1. In the cylinder printing machine, the MyWave-3D is decorated in a total of seven screen printing runs

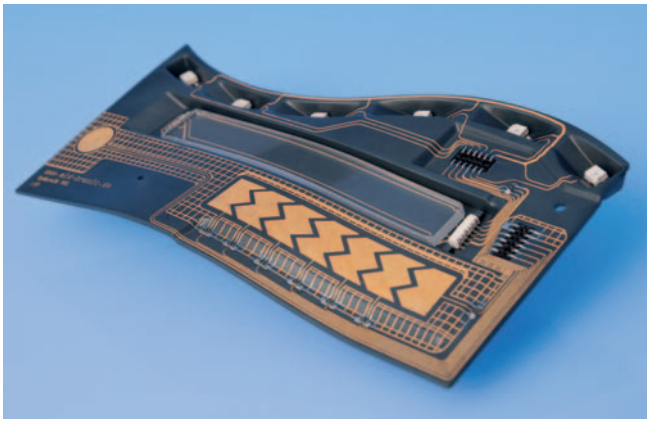

Fig. 2. The novel 3-D circuit board is provided with conductor tracks, capacitive surface (jagged region on the circuit board) and shielding (surrounding mesh surface)

The part is populated with electronic components by an own-developed SMT placement unit with a six-axis robot. Operating at up to 1 m/s with a positioning accuracy of ±0.05 mm, it applies LEDs, resistors, capacitors and other electronic components. It can act at a deformation height of up to 50 mm, while conventional placement units are limited to 20 mm. Another advantage is the angle-true population through oblique positioning of the workpiece. For example the lighting effect of LEDs can be precisely controlled and optimally utilized. The soldering of parts then takes place by a vapor phase process, which achieves a uniform temperature profile throughout, including on curved surfaces.

The 3-D circuit board contains the functional electronics but not the control electronics. In automotive engineering, it is always installed in a central control unit and thus contains essential know-how of the OEM. In addition, money can be saved and the overall height reduced. LDS, as a multi-stage manufacturing process, is more expensive than the production of conventional flat circuit boards, and the latter also offer more space for applying conductive tracks: up to 100 layers can be accommodated on 1.5 mm thickness. For future series applications, therefore, the dictum is: as much peripheral electronics as necessary (consigned to modules and circuit boards with pleasantly tactile shapes) – as much centralized electronics on flat circuit boards as possible.

One Microprocessor for Three Operating Modes

To allow the MyWave-3D Demonstrator to show what it can do, however, it was necessary to integrate a flat control circuit board with microprocessor into the part **(Fig. 3)**, by means of which three different operating modes can be chosen. Immediately after it is switched on by a gentle touch of the power button, the system displays the room temperature in binary form. That means the LEDs behind the numbers 1, 2 and 16 produce 19 °C **(Fig. 4)**. For the numbers, the KH/Foliotec team realized an effective disappearance effect (also known as black panel effect). They are almost invisible when not switched on.

Tapping again on the mode button activates an infinitely variable color change. Behind the MyWave-3D is an optical waveguide with scattering pigments that is formed for a correctly angled illumination similar to the part surfaces, RGB LEDs are mounted next to it. These red-green-blue LEDs can show all the colors of the rainbow. If you stroke your finger lightly over the volume controller printed on the part surface, the text changes color. When you have reached the desired color, you take your finger away and the color remains. The capacitive field can be adjusted so that it is not necessary to touch the plastic surface, but only to move the finger at a slight distance from it.

The third mode, via the volume control, sets off a curved row of LEDs on the upper edge of the operating element, with a long row for high volume and a short row for low volume. For control, it is possible to stroke along the volume control or only to touch it at a point. The running LEDs change depending on the finger movement.

Various Design Possibilities

As regards the decoration and backlighting possibilities, MyWave-3D already goes well beyond other concepts, which so far have only presented a three-dimensional capacitive monochrome surface. The application of control symbols is of fundamental importance for the operation of household appliances or equipment in auto cockpits. Sensory feedback, which one receives routinely at present when pressing keys or turning knobs, can be obtained acoustically when operating capacitive surfaces; in addition, raised or depressed tactile aids can be used. With the

present demonstrator, the mode button lies in a slight depression and the finger is supported on the volume control by means of a tactile rib.

In general, an extremely wide variety of surface technologies are used. As in the in-mold process, painting and printing are both suitable, and metallic effects can be obtained by means of vapor-coated metal layers or imitation-metal pigments and foils.

Other part geometries and other types of operation are possible, of course. Capacitive fields with slider or on/off functions may be circular or arcuate; the MID-Tronic team performs the electronic design with the associated mass field and the necessary matching to the part geometry. Besides capacitive circuits, inductive circuits may also be used. The two versions offer different advantages. Capacitive sensors are more sensitive and can be more precisely metered; inductive on/off circuits can be operated from distances of up to a meter.

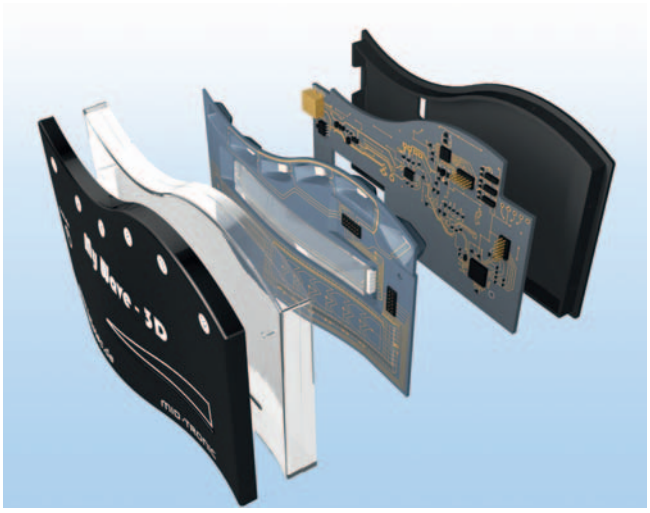

Fig. 3. The exploded view shows all layers of the MyWave-3D: (from left to right) three-dimensionally formed IML film, molded-on transparent part body, 3-D circuit board for the functional electronics, flat circuit board for the control electronics, back cover

Fig. 4. The system displays the room temperature in binary form. The LEDs behind the numbers 1, 2 and 16 produce 19 °C

The Part of the Future

While MyWave-3D is now available to interested customers and partners for testing, the specialist team headed by Wolfgang Müller (KH/Foliotec) and Karl Görmiller (MID-Tronic) is already working on the next development steps. The aim is to develop an extremely low profile, closed part that is to be produced by means of a formed functional film. The challenge is to form the film with its printed or bonded conductive tracks and fields to conform to the part geometry without it rupturing or changing its resistance. The front and back of the film are plated-through, and electronic components are soldered onto the back. The thermal stress must be kept as low as possible.

The future part then consists of a decorative film with molded-on plastic elements, as well as the formed functional film with the mounted and soldered electronic components. Light management is possible by means of special films; if the illuminated areas are small, a scattered print on the back of the decorative film is even sufficient. A special feature of this next generation of MyWave-3D will be the Liteface Display Technology (manufacturer: Deam S.A.S., Nîmes, France). Differently colored symbols can be applied at the same place on the film and if needed made visible by the use of different light filters. Where a high number of symbols are to be accommodated on a part, this technology saves a great amount of space.

Overall, a highly functional, three-dimensionally formed part of minimum height is produced, which can be used in many different industries. Besides the automotive industry, the field of consumer electronics, with household appliances that have to meet ever more challenging requirements, comes into consideration. The concept could also be interesting for the medical industry, since parts with a closed surface, with no crevices, cannot accumulate microorganisms or fluids.

Touch-sensitive operation of equipment – in all probability – will be the technology of the future. At first it will certainly be considered a complement to conventional application concepts, and there will probably always be safety-relevant emergency buttons that have to be pressed rapidly (for example, the hazard warning lights on a car). But the capacitive sensor is certain to open up new and exciting possibilities. ■

THE AUTHORESS

DR. SABINE KOB, born in 1970, is responsible for marketing and communication with Kunststoff Helmbrechts AG.