Operator control panels made of glass (Touchscreens)

Design and full area screen printing on flat glass, second surface

The term "operator control panels" includes membrane switches, front panels, and touch-screen systems, also called touch panels. They have become an innate part of everyday life. The increasing popularity of smartphones and interactive netbooks keeps inspiring other sectors to employ this technology for their devices. Products that were previously equipped with membrane switches are now provided with touch panels. The combination of modern glass design and electronics offers advantages over other materials, like durable and stain-resistant surfaces. This TechINFO includes different aspects of this topic like applications, requirements, and the respective Marabu screen printing inks.

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1.0 Structure of a Touch Panel

There are different manufacturing methods and so-called "display technologies" for the production of touch panels. Design and making of the decorative glass surfaces are the core elements for screen printing. The structure of a projected-capacitive touchscreen (p-cap) is very complex and technically demanding (see chart).

Picture: Construction of a Projection Capacitive Touchscreen

1.1 Glass substrates

The basic material is float glass. Various types of glass are used, which differ in hardness, bonding strength, colour, and fracture behaviour. The glass is often chemically treated and hardened, and anti-reflection coating is applied.

Common types of glass are for example:

- Float glass (greenish), like Soda-lime glass
- White glass, like OptiWhite™ by Pilkington
- Borosilicate glass
- Chemically hardened glass, like Gorilla® Glass made by Corning, Xensation™ made by Schott

1.2 Plastic substrates

Special plastic materials with high impact resistance are also partly used, such as PMMA or PC compounds.

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1.3 Applications and end products

Operator control panels are for example used for control and monitoring purposes in the building and medical technology. These control panels made of glass are very durable and appealing with their elegant, sophisticated, and yet functional design. These glass front panels meet highest hygienic requirements in the food or pharmaceutical industry. They are virtually not subject to any wear and thus surpass the life of mechanical keyboards.
There are plenty of design possibilities: Full-area prints, logos, or symbols, printed with transparent or effect inks like pearlescent, flip flop, metallics, or 4-colour process shades.

Applications include:

- All-in-One PCs
- Car navigation systems
- Vending machines (like for tickets)
- Computer monitors
- Digital cameras / camcorder
- Information terminals
- Netbooks, ultrabooks
- Smartphones
- Gamestations
- Tablet PCs
- White goods / glass panels, etc...

2.0 Requirements for products and inks

Resistances like:

- Adhesion according to DIN/ASTM (GT0/5B)
- High chemical resistance
- High alcohol resistance
- High mechanical resistance
- High temperature resistance with lowest DE deviations

Humidity tests like:

- Climate chamber test (Heat Soak) for 72 h at 65C°/95%RH
- Alternating climate chamber test
- Boiling test, e.g. 30 or 60 min. at 99°C

Optical requirements like:

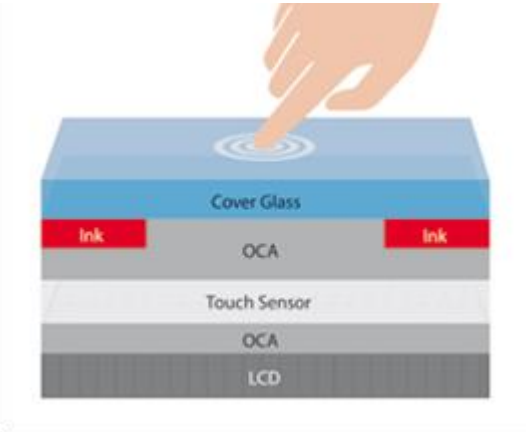
- High optical density
- Colour coordinates (Lab-values)
- Brightness value of white (L- value)
- Good ink flow
- High edge definition

Requirements to the ink structure:

- Thin ink layers
- High electrical resistance values of the ink structure

3.0 Marabu products, solvent-based

Usually, the back side of a glass is printed (second surface) (see. 1.1), as shown in the picture below, for example a border matrix.



Picture: Structure of a Touch panel

We recommend the following solvent-based ink systems for this application:

Mara® *Glass*	Colour shades	Ink system
MGHT*	Black + White	1-c Baking ink
MGL	Maracolor	2-c Epoxy

** Please see chapter 5.1 OGS for (One Glass Solution) for more information on MGHT.*

Ink builds as described below have proved to fulfil common requirements:

Ink build MGL black; glossy

MGL	colour shade	mesh	OD
1. layer	188 + hardener	165-27	> 5.5
2. layer	188 + hardener	165-27	> 6

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Ink build MGL colour shades

MGL	colour shade	mesh
1. print	932 + hardener	140-31
2. print	970 + hardener	100-40
3. print	188 + hardener	165-27

Optical density : > 5.0

Effect inks

Transparent inks and press-ready metallics are available. Special effects inks like IR or filter inks are available upon request.

3.1 Use of auxiliaries

The inks must be mixed with the respective hardener according to the Technical Data Sheet. We recommend allowing the ink/ hardener mixture to pre-react for 15 min before adjusting the ink to the desired viscosity with auxiliaries (thinner/retarder) according to the ambient printing conditions.

Attention

MGL (all Maracolor shades) is silicone-free for best flow properties, surface homogeneity, and brilliance. It is essential that a contamination with silicone is avoided for good wetting and a homogeneous ink flow.

For silicone-free inks it is important to use only thoroughly cleaned stencils, squeegees, ink pumps, as well as tubes (in the case of an automatic ink supply), and injectors for the manual ink filling of the stencil, etc.

3.2 Drying processes

Intermediate drying

Ink type / colour shade	No. of layers	Recommended temperature/time
MGL Black	2	e. g. 100°C/3-5 min
MGL White/colours	3 – 5	e. g. 100°C/3-5 min

The artwork of the second layer is usually reduced approx. 200-300µm compared to the first layer.

Final drying

The printing of the multi-layered ink structure is followed by the „Final Drying" at these recommended temperatures and time frames:

Ink type / colour shade	Recommended object temperature/time
MGL Black	140- 180°C/20-30 min.
MGL White/colours	140°C /30 min.

4.0 Marabu products, UV-curable

Ultra® *Glass*	Colour shades	Ink system
UVGL	all	2K-Epoxy
UVGO	all	2K-Epoxy
UVG3C*	Black + White	2K-Epoxy

**UVG3C features high opacity white and black shades for the high tech requirements in the 3C market*

UV-curable inks keep becoming more and more popular. The fact that they do not contain solvents offers many advantages:

Benefits of UV screen printing inks

- Unlimited mesh opening
- Excellent reproduction of details: printing of finest AM and FM halftones
- Stable colour accuracy during the print runs
- No residual solvents in multi-layered ink structures
- Very high electrical resistance
- Quick curing allows fast processing speed
- Higher quality and process safety for multi-layered ink structures
- No adjustment of the ink with thinner and retarder
- Low environmental impact, compliance with MAK values

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It is important to balance out the main properties of a UV-curable ink:

- Very good adhesion to glass
- High intercoat adhesion for multi-layered ink structures
- Good opacity with finest mesh counts and simultaneously good curability
- High durability and resistance to adhesives
- High print quality (edge definition)

The UVG3C formulations meet these high requirements; extensive internal and external tests have revealed excellent results.

Tip
Adhesion modifier should be added to the ink approx. 20-30 min prior to printing in order to achieve best adhesion.

These UVG3C shades are available:

- 170 Opaque White
- 180 Opaque Black
- 188 Tiefschwarz

Effect inks
Special UV effect inks like e.g. silver, or pearlescent blue or green are available upon request. These effects are implemented in a multi-layer structure.

4.1 Fabric selection and layer thickness

Properties such as adhesion, printing quality, optical density, layer thickness, and resistances must be balanced in order to achieve a perfect result.
We recommend the following ink structure for best opacity:

Ink build UVG3C, e.g. black

UVG3C	hardener	mesh	OD
1. layer	188 + hardener	165-27	2,3-2,5
2. layer	188 + hardener	165-27	> 5

4.2 UV curing and final curing

A completely cured ink film is essential for the stability and resistance of the UV ink film. The result is strongly influenced by the type and settings of the UV curing unit:

- Lamp intensity; recommendation 2 x120 W/cm, medium pressure mercury lamp
- Doping of the lamp (iron or gallium)
- Reflector quality and focus
- Setting : for example low or full power
- Adjustable production or belt speed

The result is furthermore influenced by:

- The printed ink film thickness is depending on the mesh count, printing plates, flood bar, and printing speed, as well as quality, grind, and angle of the squeegee
- Formulation of the ink (e.g. opaque shades)

Tip
For highest brightness values (L-value) and least possible yellowing of UV opaque white ink structures it may be beneficial to use an iron-doped, ozone-free lamp (solarisation of glass).

Post-treatment
Post-curing and post-treatment is also decisive for the resistance of the UV ink. Whether or not a post-treatment is necessary depends upon the production process and steps, and must be tested under production conditions. For tests in terms of the required resistances such as constant climate chamber test or alternating climate test, we recommend a wait time at room temperature for at least 24 hours. Best resistances for post-processing like gluing are achieved with an IR dryer or short tempering at 140°C/10 minutes.

4.3 Comparison UV vs solvent-based

	UV	Solvent-based
Machine	¾-full automatic	½-automatic
Drying, curing	UV	Oven / IR
Post-treatment	If necessary	Oven, e.g. 180°C/30 min.
Productivity	high	medium / low
Mesh	120-34 to 180-27	77-55 to 165-27
OD*, Black	1 layer 2,3-2,5	1 layer > 4.5

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	2 layer > 5	2 layer > 6
Ø layer thickness (mesh 165-27)	1. layer 6-7µm 2. layer 6-7µm total: 12-14µm	1. layer 3-4µm 2. layer 3-4µm total: 6-8µm

*Optical density

5.0 Touchscreen Technologies

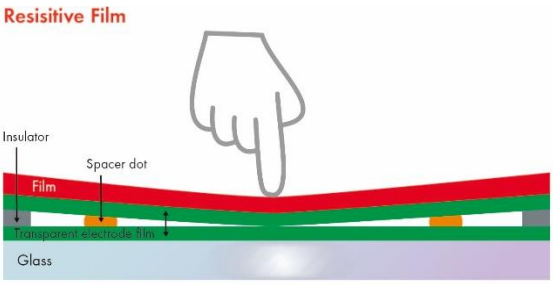
There are several module technologies and manufacturing techniques: so-called „resistive" or „capacitive" touchscreens.

Resistive Touchscreens

As the word already implies, a resistive touchscreen responds to pressure. It consists of two layers: the upper layer is made of polyester and the bottom layer is usually made of glass. Only little pressure is required to trigger the impulse. The facing surfaces are coated with indium tin oxide, a light transmitting semiconductor.

If for example direct current voltage is applied to the bottom layer, and if then the layers are pressed together, the electrical circuit boards touch and the voltage is measured at the edges of the upper polyester surface, resulting in the position of the pressure point.

Resistive Touchscreens are for example used for smartphones which come with a pen or stylus, which is not that common anymore. They have a much smaller and therefore more precise pressure point than a fingertip.

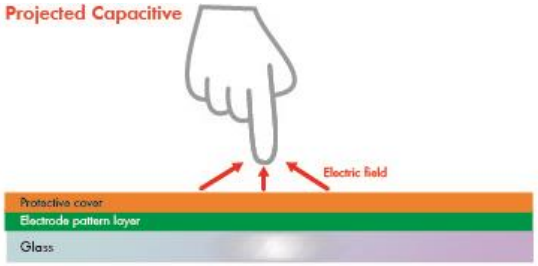


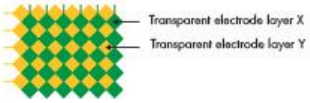
Projected-capacitive Touchscreen (P-cap)

Latest developments are based on the technology of capacitive resistance. Contrary to a resistive touch screen, a capacitive touch screen does not require any mechanical pressure. The screen does not consist of several layers but only a glass plate. The sensor is constructed with two IT-coated layers (indium tin oxide).

As the human body is an electrical conductor, simply by contacting the display with a finger results in a changed electrostatic field and thus an electrical impulse. The dispatched current flow is measured at the corners to determine the position of the finger. Disadvantage: Such a display cannot be used if you are wearing gloves for example.

The main advantage of the „P cap systems" is that the sensor can be mounted on the back of the cover glass, and the detection is "projected through" (hence the name). Thus, it can be operated on the virtually wear-free glass surface. Furthermore, the detection of gestures and plurality of touch ("multi touch") is possible. This touch version is being used by practically all smartphones and tablet computers nowadays. There are different types of P cap touchscreens which can roughly be categorized as "glass type", or "film type".





5.1 OGS (One Glass Solution)

A newer and more efficient technology, employing only one glass layer which is even thinner, for lighter and thinner end products is called "OGS","One Glass Solution".

Structure comparison:

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Common OGS requirements

- Very high chemical and mechanical resistance
- Highest temperature resistance over 300°C (ITO-Sputtering)
- Very high optical density
- White with high brightness value ("L" value)
- High electrical resistance values $>10^{12}$ Ω
- Very thin ink layers
- Smooth, homogeneous ink film surface

Mara® *Glass* MGHT

The solvent-based ink Mara® *Glass* MGHT (HT = High Temperature) is a 1-component baking ink for high temperature applications. Several colour shades are available.

Drying

Overprintability is achieved after 5 min. at 180°C. The recommended min-max baking temperature and time for the entire ink structure is 30 min. at 250-330°C. This allows the ink film's crosslinking process to accomplish and results in highest resistances.

ITO-Sputtering

This manufacturing method describes the coating of the printed ink film with a transparent conductive layer, Indium Tin Oxide (ITO), in a sputtering process. This takes place at very high temperatures which expose the ink to temperatures of 250°C - 330°C. Therefore, the ink must provide highest temperature resistance (pigments and binder). The printed ink layer should be as thin as possible with lowest RZ values (smooth, homogeneous surface).

6.0 Pre-treatment of glass surfaces

For best adhesion and linkage of the ink film we recommend printing onto the air or fire side of the glass material, as well as a pre-treatment of the glass surface.

Such pre-treatment may include:

- Pre-cleaning the glass surface with demineralized water
- Pre-cleaning with special glass cleaners
- Pre-cleaning in a dishwasher
- Plasma /Corona-pre-treatment
- Flame pre-treatment
- Silane pre-flaming

The glass surface must be free of residues such as dust, dirt, grease, etc., or otherwise adhesion will be reduced. As to our experience, the highest quality in terms of adhesion and moisture resistance (delamination of the ink film) is achieved with pre-flaming or Silan pre-flaming.

7.0 Marabu tests

Marabu carries out standard tests for these applications:

- Climate chamber tests, constant/ alternating
- Xenon test
- Electrical resistance measurement, with tera-ohmmeter
- IR-Transmission
- Abrasion test, with Taber Abraser
- Determination of the degree of gloss

Test criteria are for example:

Test	Test Method	Requirement
Opt. Density	Gretag Macbeth	> 2,5 – 6
Degree of gloss	60° and 20° angle, Tool: Byk Gardner	specific
Adhesion 24h water soak test	Cross hatch tape test EN ISO2409/ASTM3359	GT0 / 5B
Condensated water	30M./ 70°C/100% RH	GT0 / 5B
Climate chamber	72h / 65°C /95% RH e. g. 6 cycles	GT0 / 5B
Alternating climate chamber test e.g.1 cycle 14h	65°C/90%- cooling - 20°C e. g. 6 cycles	GT0 / 5B
Boiling test	30-60 Min. @99°C	GT0 / 5B
Chemical resistance	e.g. MEK; Alcohol 99.8%, Tool: Taber-Abraser, e.g. 850gr.	Marabu abrasion level 1-5
Electrical resistance	Tera-ohmmeter TO 3	> 108

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8.0 Prospects

The Marabu ink lines Mara® *Glass* MGL, Ultra *Glass* UVGL und UVGO, together with the specially adapted, high opacity ink lines, UVG3C and MGHT build the perfect basis for these applications.
The use of UV inks increases the process safety and speed of multi-layered structures and expands the range of design possibilities for flat operator control panels made of glass (especially for 4 colour process printing and technical halftone gradients (AM and FM halftones).

8.1 Remarks

The advice in this TechINFO is based on our current knowledge. Nevertheless, before production start, the individual conditions (stencil, printing pressure, curing, post-processing, etc.) must be considered, tested and approved on site.

Contact

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Common abbreviations

AF	Anti-Finger
AG	Anti-Glare (Anti-Reflection)
AMOLED	Optimized TFT-LCD
AS	Anti-Smudge
BM	Border Matrix/Black Matrix
BP	Back Plate
CG	Cover Glass
FPC	Flexible Printed Circuit
GF	Glass to Film
GG	Glass to Glass
IR	Infrared
ITO	Indium Tin Oxide
LCD	Liquid Crystal Diode
OC 1/2	Overcoat Layer 1/2
OCA	Optical Clear Adhesive
OCR	Optical Clear Resin
OGS	One Glass Solution = TOC/TOL
PSA	Pressure Sensitive Adhesive
TFT	Thin Film Transistor
TOC	Touch On Cover
TOL	Touch On Lens
TPM	Touch Panel Module

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