DCL TEK

PCAP Touch Panels

How they Work

How they are Made

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Types of PCAP Touch Sensing

- Mutual Capacitance
  - Electromagnetic fields are created using conductors separated in the z-axis
  - Generally the most robust and highest performance PCAP touch sensing technology
  - Many IC and pattern design options
  - More expensive than Self Capacitance because two conductive layers are required
- Self Capacitance
  - Electromagnetic fields are created using conductors on the same layer
  - Lowest cost (single layer design)
  - Inherent water rejection
  - Poor accuracy (typically 3mm – 4mm errors)
  - Single touch with limited gestures only
  - Advanced Self Capacitance designs allow multi-touch and good accuracy, but have yield challenges

How a Typical Touch Panel Works

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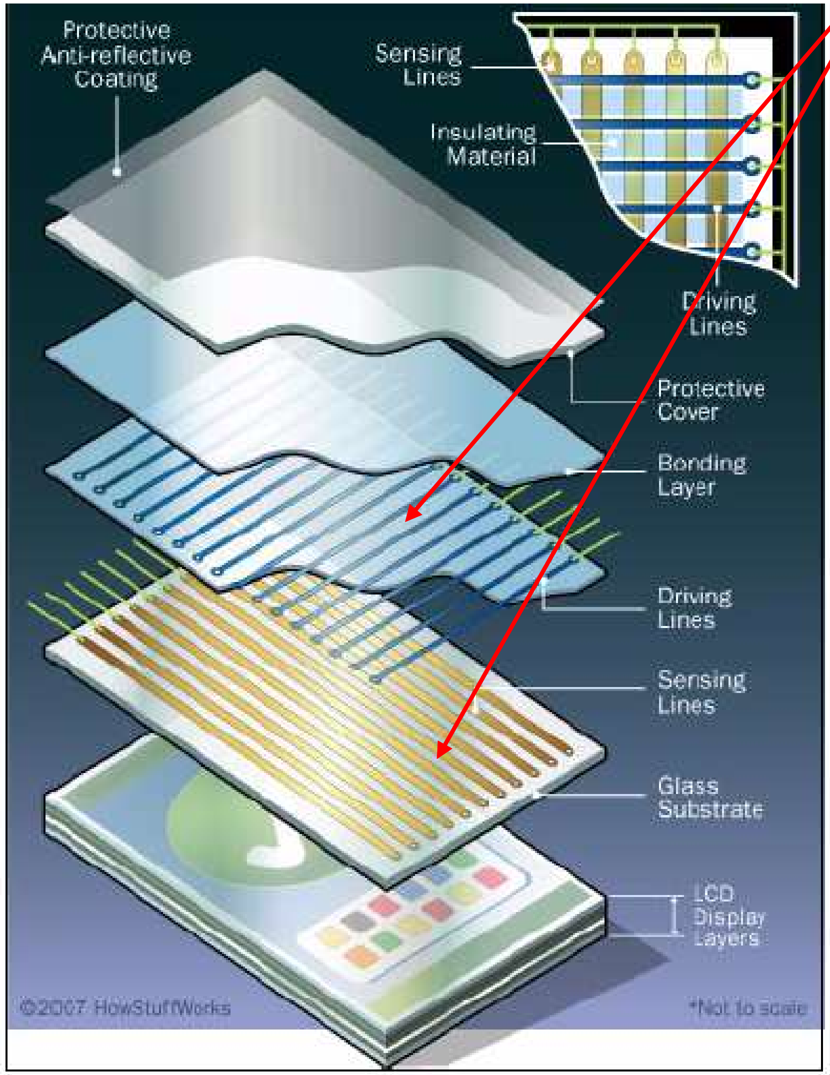
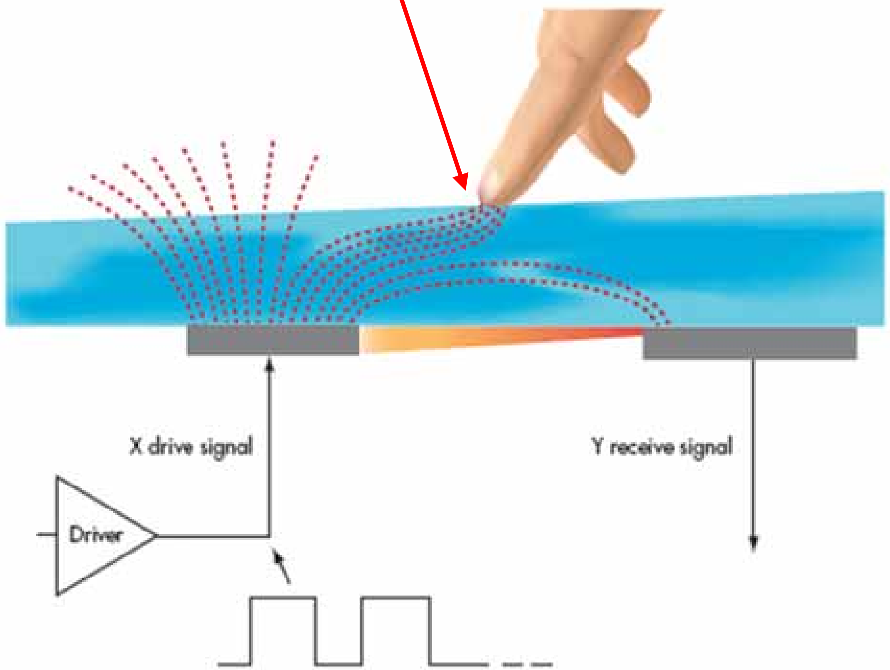


These two layers create a grid

The finger interrupts the electromagnetic field, and draws a small amount of power reducing the capacitance value between electrically conductive traces



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How a Typical Touch Panel Works

Think about a touch panel as a grid that can detect where you are touching on it.

- One layer of the touch panel has electrically conductive lines running in one direction, and another layer has electrically conductive lines running in the perpendicular direction.
- The two layers laminated together creates a grid.
- The touch panel detects where you are touching by creating electromagnetic fields between the two layers of electrically conductive lines.
- Think about this as a magnet (with a north and south pole) sitting at the intersection of each electrically conductive line. Just like a magnetic field projects above and around the north and south poles, an electromagnetic field projects an electromagnetic field above and between the lines on the grid.
- This field projects through the glass you would touch on a typical smart phone. When your finger comes in contact with the glass, a small amount of electricity is absorbed into your finger.
- That electricity absorption changes the capacitance between the electrically conductive lines. That capacitance change is measured by the touch panel controller, and the controller tells the device where the user is touching.

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PCAP Stack-Ups

- Naming rule for projected capacitive sensor structures: The first (G) refers to the cover glass (plastic or sapphire) and the other letters refer to details of the structure. Sensor structures are very complicated and have many conventional names.
- DITO and SITO: Double-sided or single-sided ITO describe the location of the X-Y ITO electrodes on a single sensor substrate. SITO usually means there is a (metal) bridge cross to insulate the X-Y electrodes (using a photolithography line).
- OGS: The one-glass solution was called sensor on cover. Because there is only one side left for sensor patterning, OGS usually adopts a SITO pattern.
- GF1 has a single film layer with multi-touch. It is also known as the caterpillar pattern.
- G1F has the electrodes separately located on the cover glass and film.
- GFΔ has a triangular pattern unit to support gesture touch.

Sensor Structure	(G)GG	(G)G SITO	(G)G DITO	OGS	(G)1F	(G)FF	(G)F DITO	(G)F Single	(G)F Triangle
Also Known As	GGG	GG	GG, DITO Glass	OGS, G2	G1F, GFM	GFF	GF2, DITO film	GF1	GFΔ
Substrate #	2	1	1	1	2	2	1	1	1
Substrate Material	Glass/Glass	Glass	Glass	Glass	Glass/Film	Film/Film	Film	Film	Film
Y Electrode	Glass #1	Glass: top	Glass: top	Glass: bottom	Glass: bottom	Film #1	Film: top	Film: top	Film: top
X Electrode	Glass #2	Glass: top	Glass: bottom	Glass: bottom	Film: top	Film #2	Film: bottom	Film: top	Film: top
Remarks	almost none	SITO bridge for insulation		SITO bridge for insulation				traces insulation	no bridge, no insulation

Cover Glass	Cover Glass	Cover Glass	Cover Glass	Cover Glass	Cover Glass	Cover Glass	Cover Glass	Cover Glass
Y Lines	X-Y Lines	Y Lines	X-Y Lines	Y Lines	Y Lines	Y Lines	X-Y Lines	Δ Pattern
Glass	Glass	Glass		Adhesive	Film	Film	Film	Film
Adhesive		X Lines		X Lines	Adhesive	X Lines		
X Lines				Film	X Lines			
Glass					Film			

Note: SSG is similar to OGS but a simple sensor glass without cover glass finishing and shaping.

Touch Sensor Substrates

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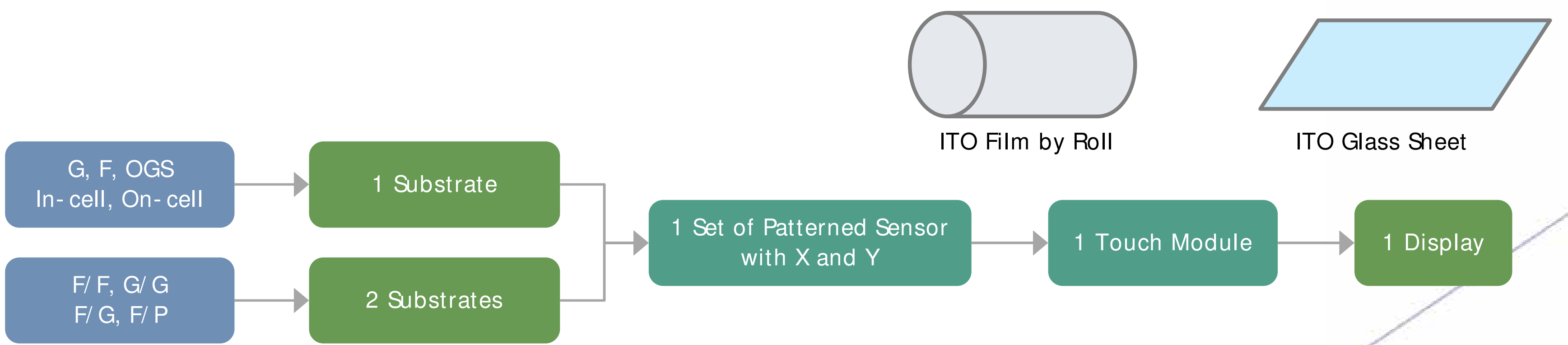
- Sensor substrate for patterning
  - A transparent conductor (typically ITO) is sputtered on plastic film (typically PET) or glass. It forms the ITO film or ITO glass.
  - Non-patterned substrate: The sensor substrate(s) bears ITO sputtering but is not patterned yet.
  - In resistive touch, fully coated ITO film or glass is typically laminated onto the touch sensor.
  - Patterned substrate: With projected capacitive, the ITO film or glass needs ITO patterning. Typically, chemicals or lasers are used to etch out the ITO, forming the desired pattern. Some patterns are simple ITO lines. Others have a snowflake or triangle wedge pattern. It all depends on the company's IP. The patterned ITO film or ITO glass is laminated into the touch sensor. Therefore, resistive touch typically has a high yield of >90%. Projected capacitive currently has yield of 60-95%.
- Substrate area and sensor area
  - A set of patterned substrates is defined to include both X and Y patterned circuits. However, it could require one piece of sensor substrate (such as the G structure) or two (such as the F/F structure) to make a touch sensor. Therefore, the substrate area can be either 1X or 2X the touch sensor's. For example, F/F usually consumes more than twice as much substrate area as its yielded sensor area.



ITO Glass vs. ITO Film

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- Glass can bear >300°C in the ITO sputtering process and can achieve a surface resistance less than 20Ω/sq. In contrast, most film substrates for touch, such as PET, cannot bear a high temperature process.
- In addition to better heat resistance, the material permittivity is higher for glass than for film, which results in the lower resistance of ITO glass.
- The transmittance does not differ much between glass and film. Both can achieve sufficient quality. But the GFF type needs one layer of OCA between the two film layers. The haze from OCA decreases the final transmittance of the touch module.

	ITO Glass	ITO Film
Surface resistance	Low (10Ω/sq.)	High (>140Ω/sq.)
Permittivity of substrate material	High (3.7-10.0)	Low (2.9-3, PET)
Thickness of sheet	Thicker (>0.33 mm at commercial level, 0.1 mm at R&D level)	Thinner
Transmissivity of the sheet	>90%	<90%
Pattern visibility	Less visible	visible
Durability of ITO layer	Good	Depends on crystalline type

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Glass / Film / Film (GFF) Structure

You will see and hear touch screen, touch module, and touch panel used interchangeably. All of these terms refer to the image above.
A touch sensor is the image above minus the Cover Glass, FPC / COF, and the touch screen controller (a touch screen controller is bonded to the COF)

- Cover Glass is the glass surface you are accustom to touching on your smart phone
- OCA stands for Optically Clear Adhesive: This material is used to glue layers of the touch panel together, and it is completely transparent.
- TCF stands for Transparent Conductive Film: This material allows electricity to flow through it, but is transparent. Most TCF is made from a material called ITO, so TCF and ITO are often used interchangeably.
- Ag Ink is a highly conductive silver based ink used to connect the grid lines to the FPC / COF. Ag Ink is not transparent, so it always runs under the colored border framing the display.
- FPC stands for Flexible Printed Circuit: The FPC connects the touch sensor to the electronics in a device. An FPC is also called a “ribbon” sometimes.
- COF stands for Chip On Flex: The COF is an FPC with a touch panel controller chip bonded to it. This is done to save room in other parts of a device.

Glass / Film / Film (GFF) Structure

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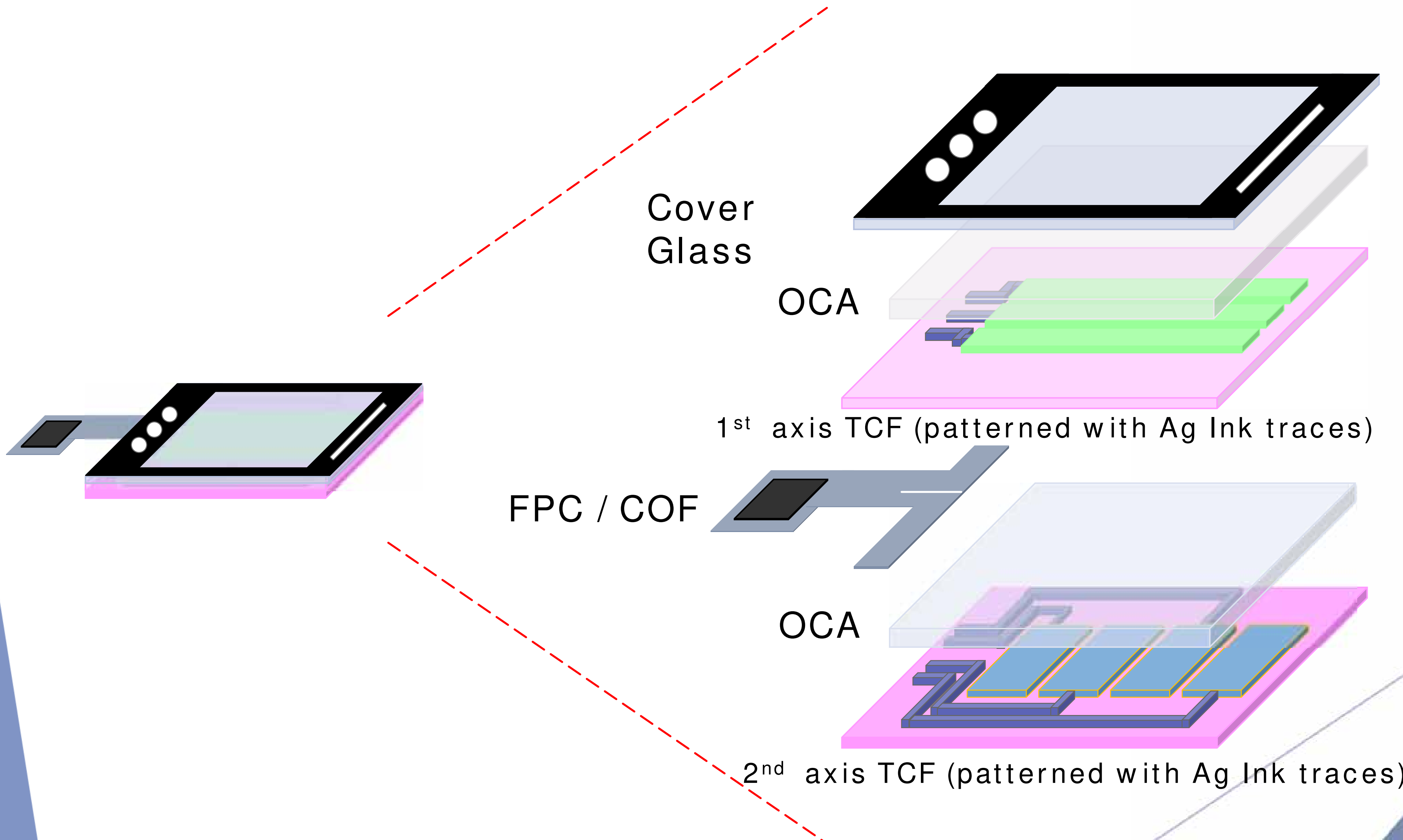

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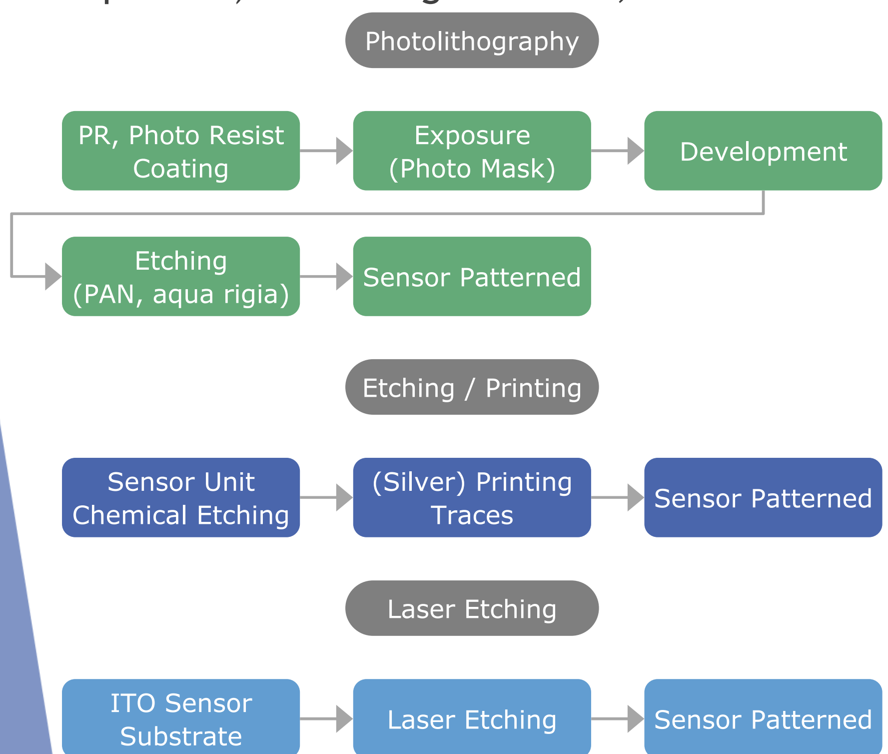
Etching Processes

- Conventionally, the photolithography process at 400°C uses glass as the sensor substrate. A low-temperature (~140°C) process for film has been available since 2011, which offers the advantages of both thinness and photolithography precision.
- Etching/printing is popular for film-based makers because of the previous resistive FF or FG process. Its sampling lead-time and equipment cost for depreciation are more competitive. However, its major advantage is the precision of the line pitch, which creates heavier traces. For some premium smartphones and tablet PCs, a narrow bezel is a must.
- Laser etching has no need for chemicals. It is a dry process. But laser etching has a dust issue (during the process) and a long takt time, unless it uses a multi-beam.



Comparison	Photolithography	Etching/ Printing	Laser Etching
Precision	<10-50 μm	50-100 μm	20-50 μm
Sampling	longer lead time	short time	very flexible
Initial Cost	mask fee	affordable	Affordable
Unit Cost	low if high volume	low	higher for long takt
Equipment Cost	very high	affordable	Affordable
Throughput	very good	acceptable	poor, unless multi-beaming
Process	complicated	complicated	simple
ITO Etching	wet (can be dry)	wet	dry & green
Substrate	G, F	G, F	G, F
Pros	process on sheet basis (Gen.) & high precision	low investment with good output	simple and easy to change pattern
Cons	not flexible for mask and cost	poor precision for conductive lines	not easy to enlarge capacity

1st Axis TCF Process

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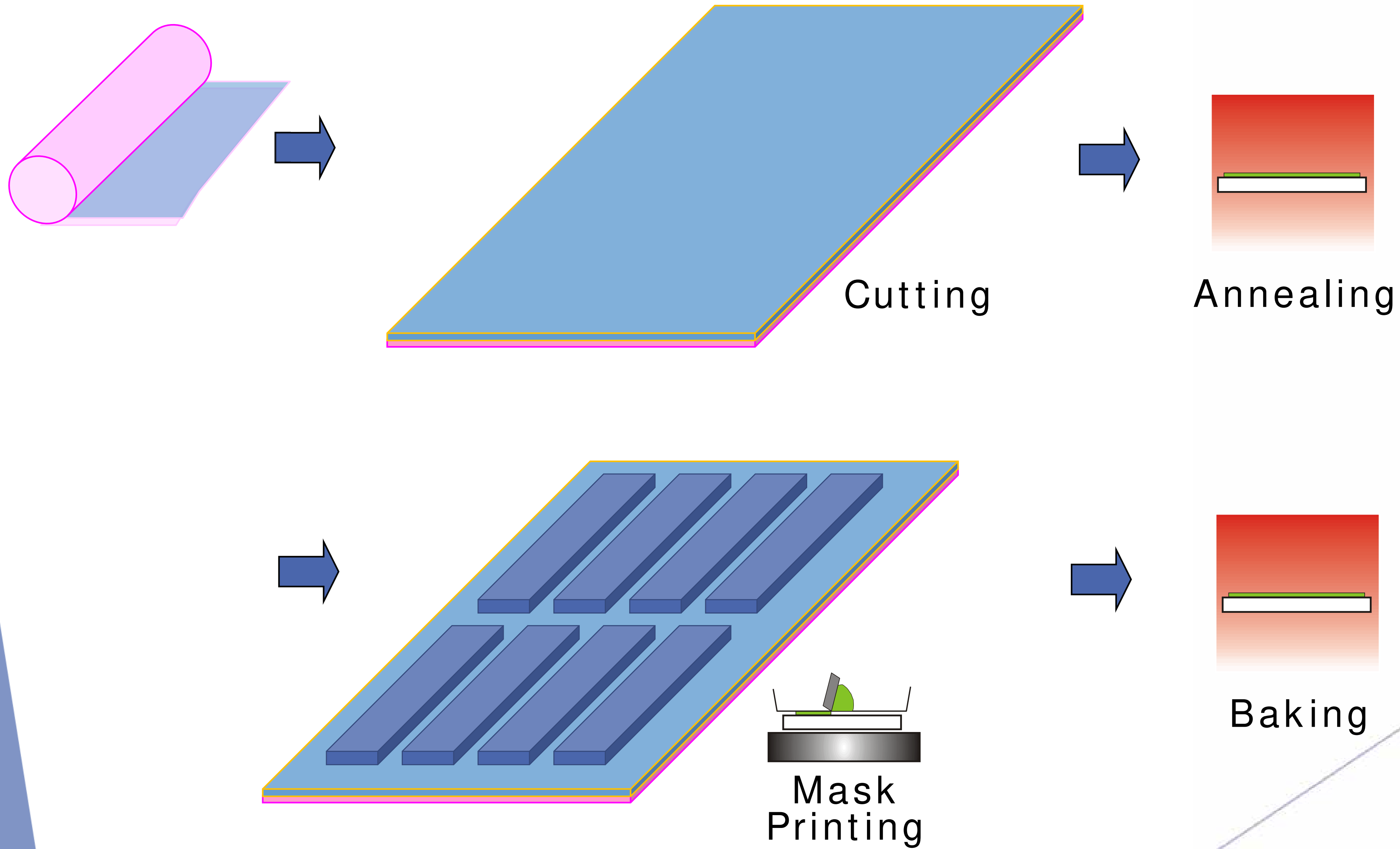

A sheet of TCF is cut off of a TCF roll. That sheet is then annealed (heated) at very high temperature (~150°C).

Then an electrically protecting mask is printed on the surface. This mask is used just like masking tape when you are painting to protect areas you do not want painted. The electrically protecting mask protects areas underneath it from electrical damage. The sheet is then baked to cure the mask.

1st Axis TCF Process (continued)

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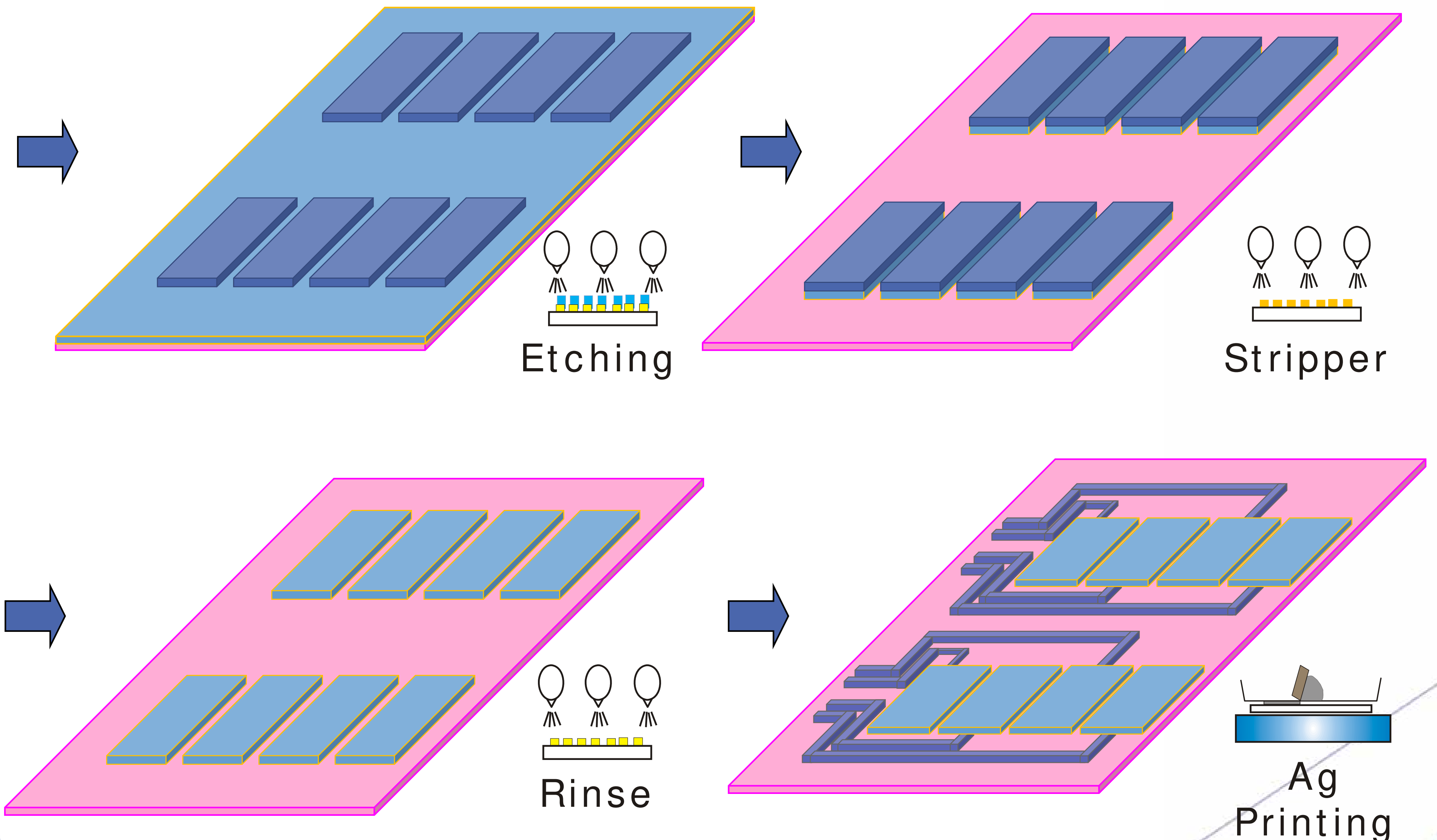

Next, an acid solvent is washed over the sheet. This acid removes all of the conductive material (typically ITO) except in the areas protected by the mask. After that, the mask is removed with a stripper solvent (yes, this is the industry term), and then the whole sheet is rinsed off. After this step, one set of transparent electrically conductive lines has been created.

The next step is printing the Ag (silver) Ink traces that connect the transparent electrically conductive lines to the FPC.

2nd Axis TCF Process

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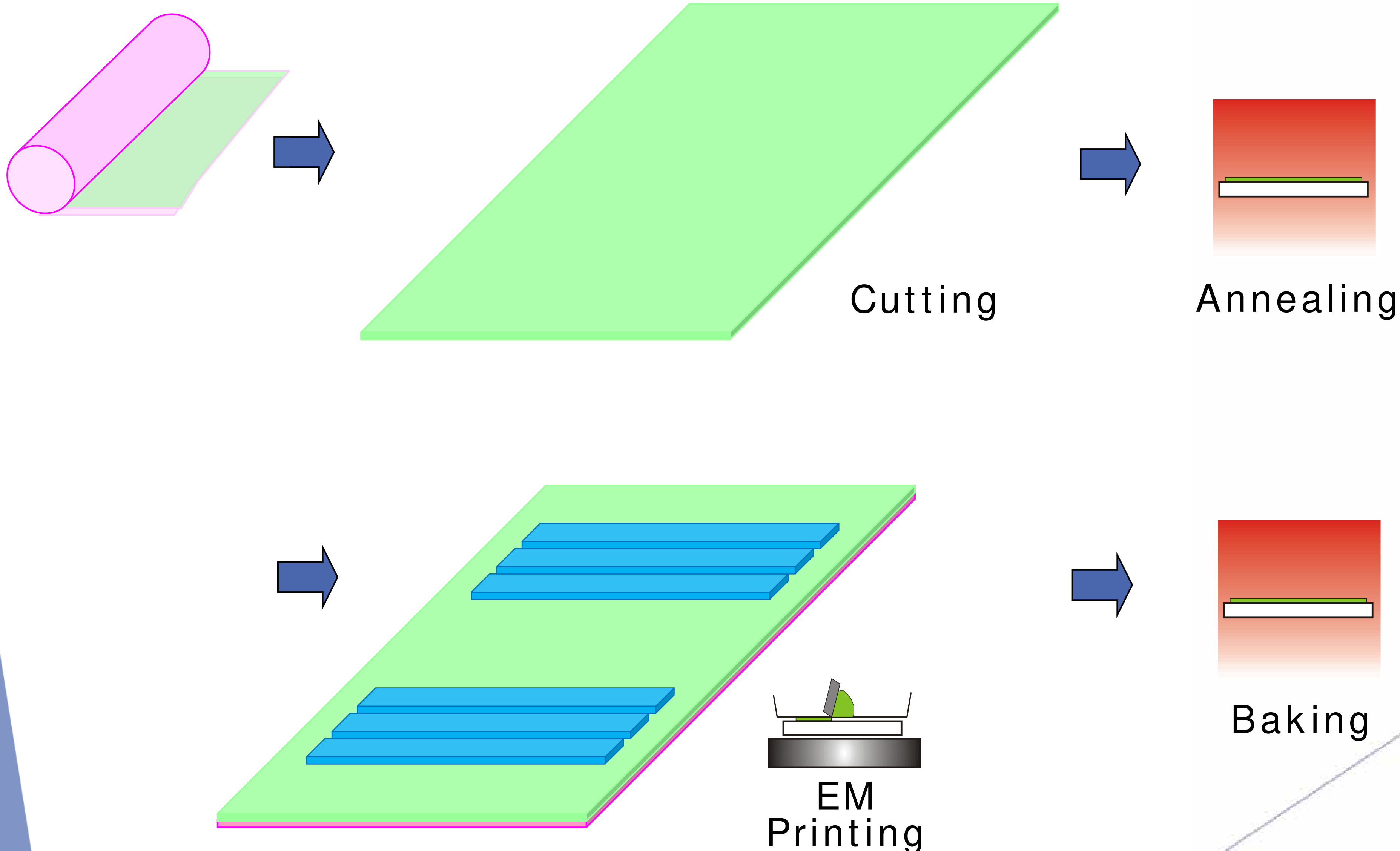

A new sheet of TCF material is cut from the TCF roll, and all steps performed on the first sheet are repeated on the new sheet. The only difference is that the transparent electrically conductive lines are running in a perpendicular direction.

2nd Axis TCF Process (continued)

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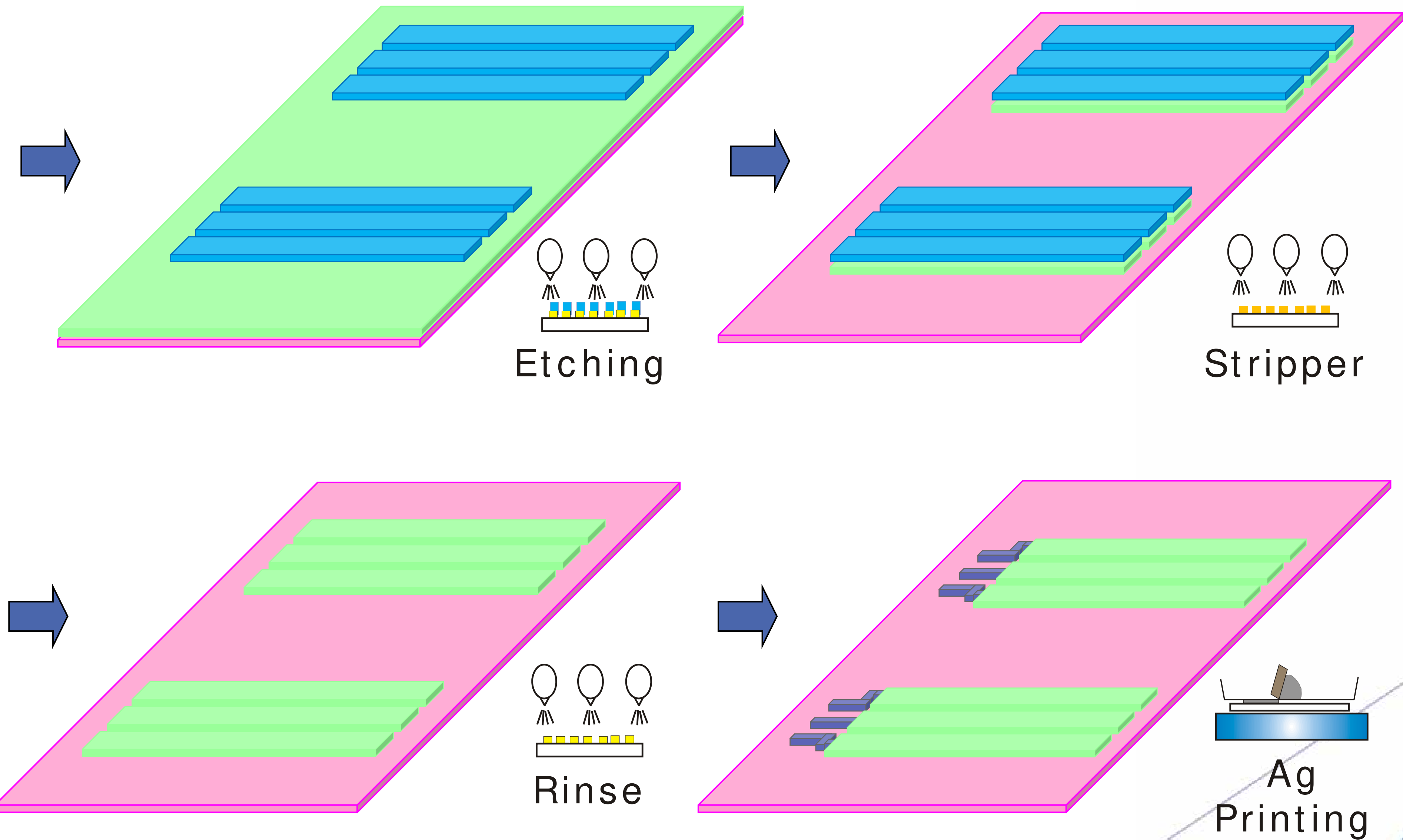

Same processes as the first sheet.

Assembly Process

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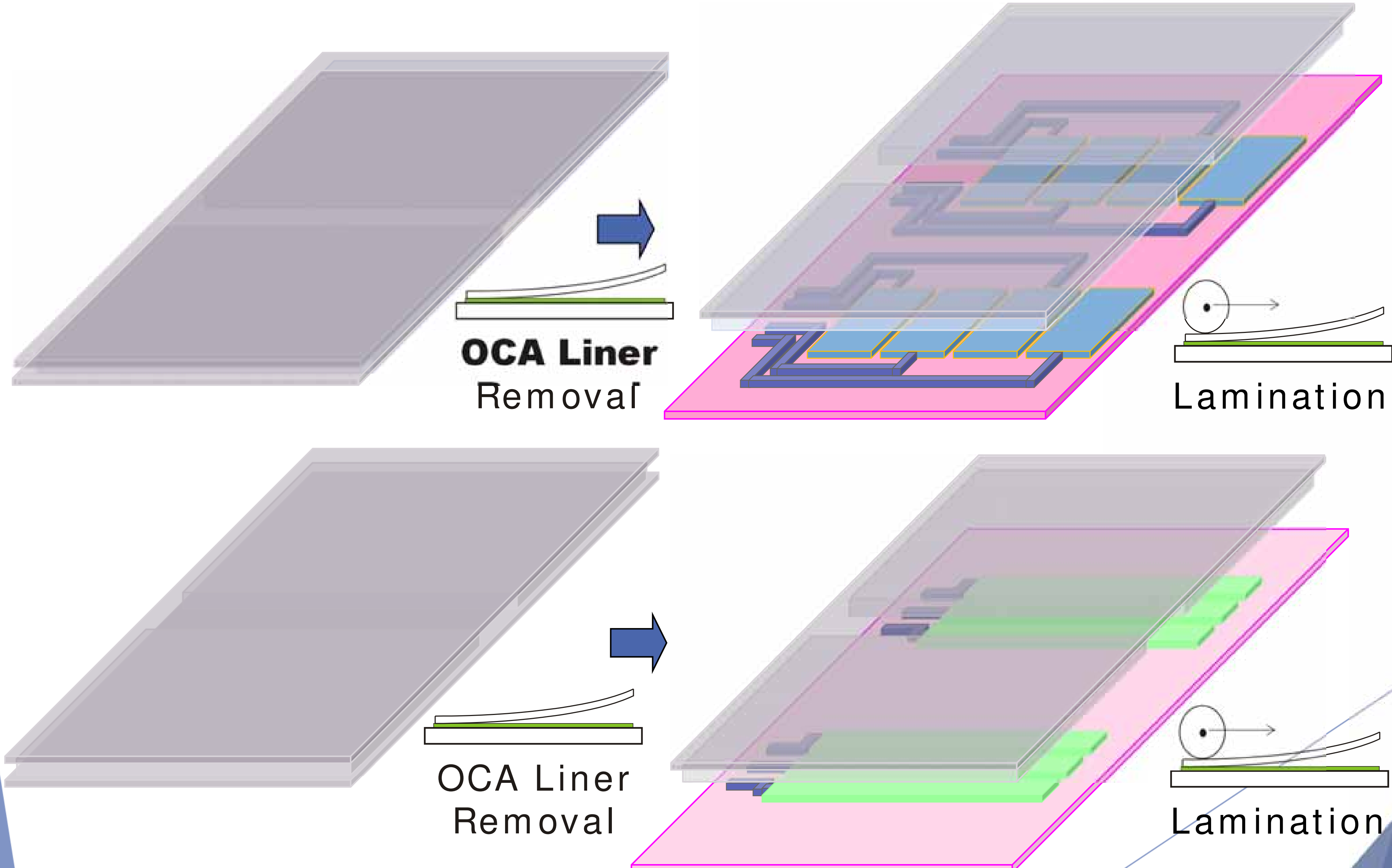

OCA is shipped on a roll between two release liners. One of the release liners is removed, and the OCA is adhered to the first layer of patterned TCF. The same process is done to the second layer of TCF.

Assembly Process (continued)

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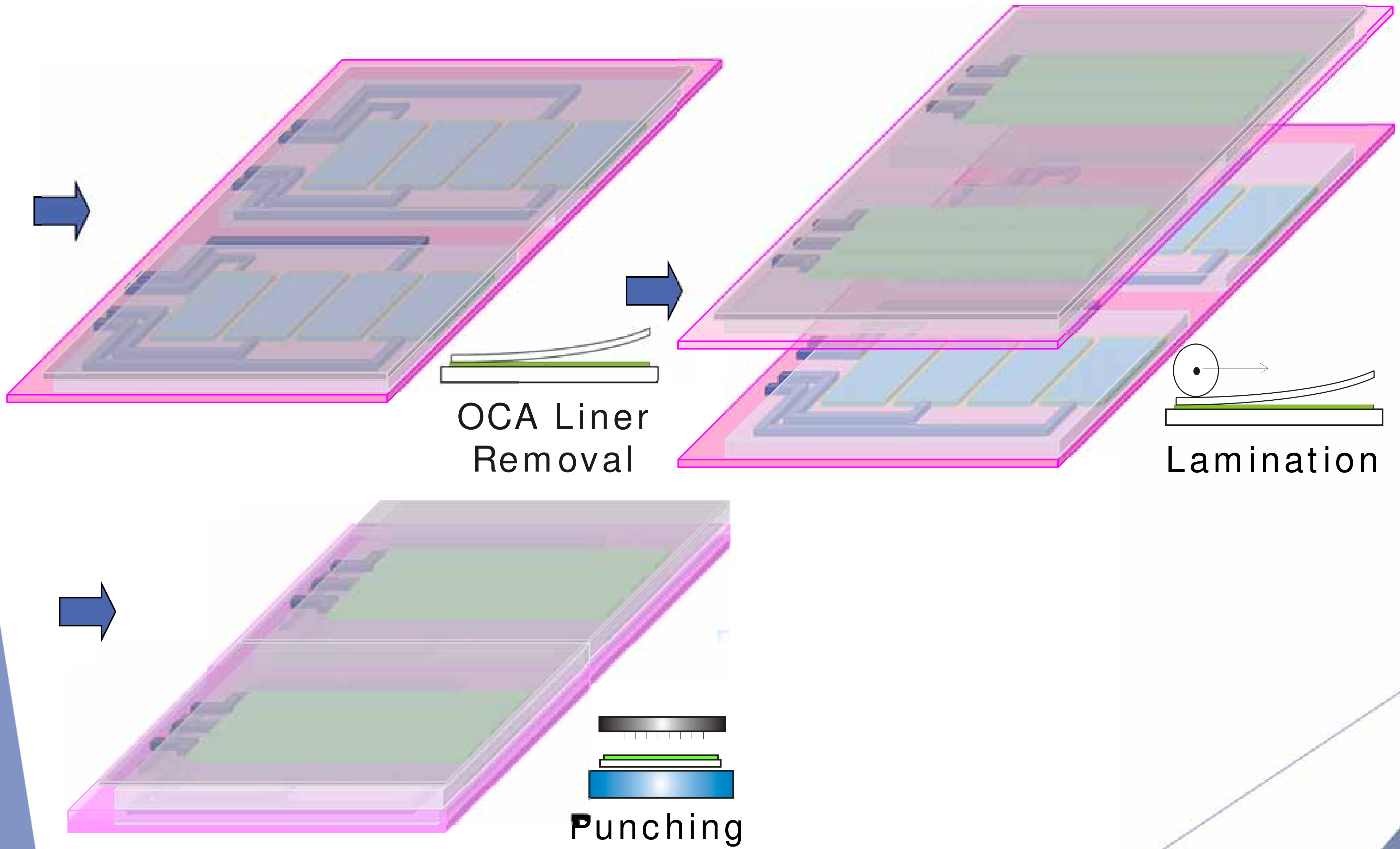

Then, the second layer of release liner is removed off the OCA laminated to the first layer of TCF, and the second layer of TCF is laminated to the first layer of TCF. At this point, there is a sheet of touch sensors. The touch sensors are then die punched out of the sheet.

FPC Bonding & Final Assembly

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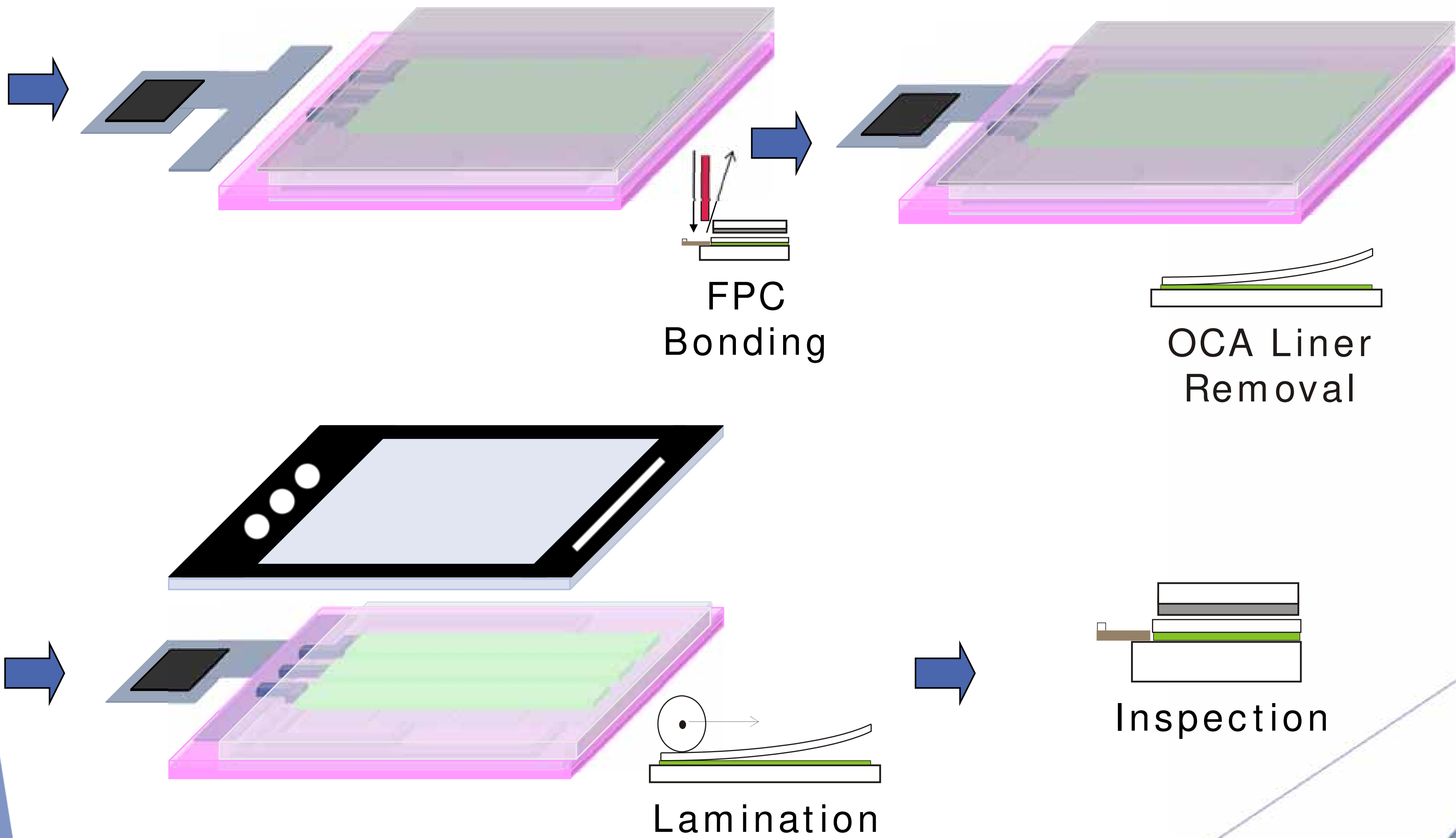

Finally, the FPC / COF is bonded to the touch sensor using a material called ACF (Anisotropic Conductive Film). Finally, the final layer of release liner is removed from the OCA, and the cover glass is laminated to the touch sensor. This is now considered a touch module, touch screen, or touch panel. All pieces go through 100% inspection to remove and touch modules with optical defects.

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PRODUCTS & SERVICES

Touch Panels

DCL has the right experience in the design, tuning and bonding of Projected Capacitive (PCAP) Touch Panels for all applications.

While we leverage existing designs whenever possible, most successful results come from purposefully designing your touch screen user interface to your application and use case requirements. Doing so ensures a high performing and priced right touch panel solution.

We make it EASY to design, prototype and deliver the specific touch solution for your application.

Key Elements of a Great Design

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Cover Lens

The cover lens, or front surface of a touch panel, represents the look and feel of your product. This is the first surface your customers are likely to engage and possibly where perceptions of quality and user experience start to emerge.

Cover lens design elements include:

- Material choices based on durability and optical expectations
- Shapes, masking, artwork and logos
- Drilled Holes
- Edge treatments

Controllers

Touch sensor controller choice is an important element in a well designed touch enabled solution. Not all controllers or makers should be considered equal. Application, use case and end user experience should define the best design choices.

Important considerations include:

- Support for rain, chlorinated, salt water and other conductive liquids rejection, heavy glove use, multiple touch points
- Interfacing requirements such as I2c or USB
- Custom flex tail shapes and connection termination type
- Longevity, price points and engineering support

Firmware

The firmware of the selected controller can be adjusted to ensure the touchscreen delivers the best performance for its intended application. Also known as tuning, firmware modifications may be required to support:

- Specific cover lens materials and thicknesses
- Gloved finger inputs of various material types
- Rejection of false touches caused by water droplets or electrical interferences
- Improved immunity to EMI through software filtering
- and other custom use case features

DCL works directly with all touch controller makers and our touch factory engineers are of the best in the industry.

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Standards to get you started

Choose from our standard touch panels for rapid proto-typing, small volume needs or the foundation for a custom design.

Product ID	Type	Size	Part No	Structure	Touch IC	Transparency	Surface Hardness	FPC Type	Interface	A/A Outline Dimension (mm)	Outline Dimension (mm)
T0101	PCAP	7"	B070PFU-E04	G/G	EETI	85%	6H	COF	USB / I2C	155.24 x 87.12	164.9 x 100
T0102	PCAP	10.1"	B101PFU-E03	G/G	EETI	85%	6H	COF	USB / I2C	217.56 x 136.2	247.76 x 166.4
T0103	PCAP	11.6"	B101PFU-E03	G/G	EETI	85%	6H	COF	USB / I2C	257.32 x 145.18	287.32 x 191.18
T0104	PCAP	12.1"	B121PBU-E03	G/G	EETI	85%	6H	COB	USB / I2C	246.76 x 185.32	260.5 x 204
T0105	PCAP	12.5"	B125PFU-E02	G/G	EETI	85%	6H	COF	USB / I2C	277.48 x 156.52	318.48 x 204.52
T0106	PCAP	13.3"	B133PFU-E02	G/G	EETI	85%	6H	COF	USB / I2C	294.76 x 166.24	330.76 x 214.24
T0107	PCAP	14"	B140PFU-E02	G/G	EETI	85%	6H	COF	USB / I2C	310.31 x 174.99	346.31 x 222.99
T0108	PCAP	15"	B150PBU-E03	G/G	EETI	85%	6H	COB	USB / I2C	305.13 x 229.1	326.5 x 253.5
T0109	PCAP	15.6"	B156PFU-E03	G/G	EETI	85%	6H	COF	USB / I2C	345.24 x 194.68	395.24 x 244.68
T0110	PCAP	17.3"	B173PFU-E02	G/G	EETI	85%	6H	COF	USB / I2C	382.89 x 215.8	432.89 x 265.8
T0111	PCAP	18.5"	B185PBU-E01	G/G	EETI	85%	7H	COB	USB / RS232	410.8 x 231.4	446.05 x 271.18
T0112	PCAP	21.5"	B215PBU-E05	G/G	EETI	85%	6H	COB	USB / RS232	477.7 x 269.4	517 x 315
T0113	PCAP	23.8"	B238PBU-E01	G/G	EETI	85%	6H	COB	USB / RS232	528.6 x 298	570 x 343
T0114	PCAP	27"	B270PBU-E03	G/G	EETI	85%	6H	COB	USB / RS232	599 x 337.7	629 x 372
T0115	PCAP	32"	B320PBU-E01	G/G	EETI	83%	6H	COB	USB	699.4 x 393.85	744.5 x 438.5

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Contact DCL to discuss designing your new PCAP Touch Panel and LCD solution

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