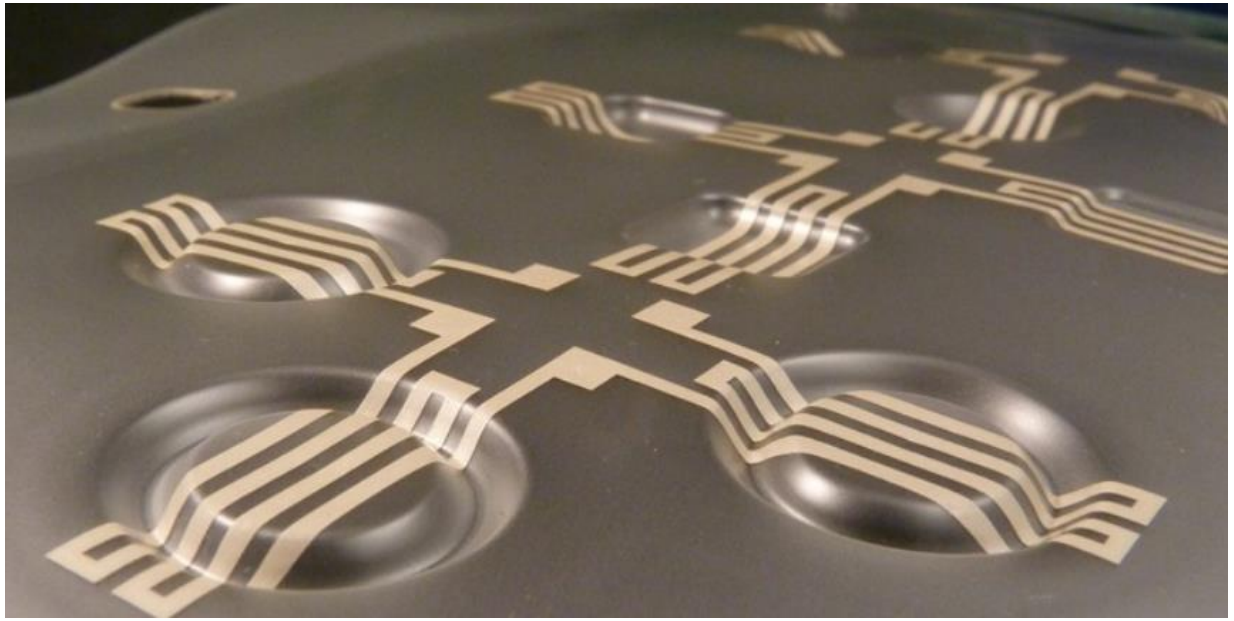
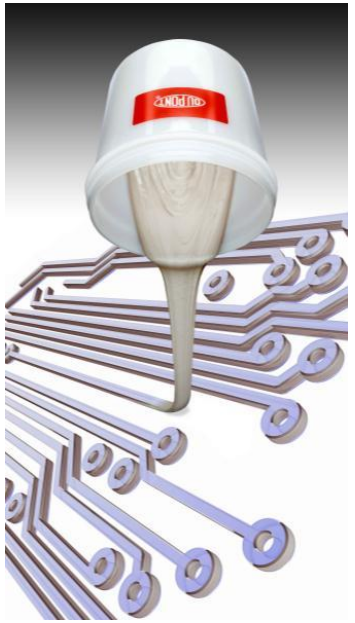
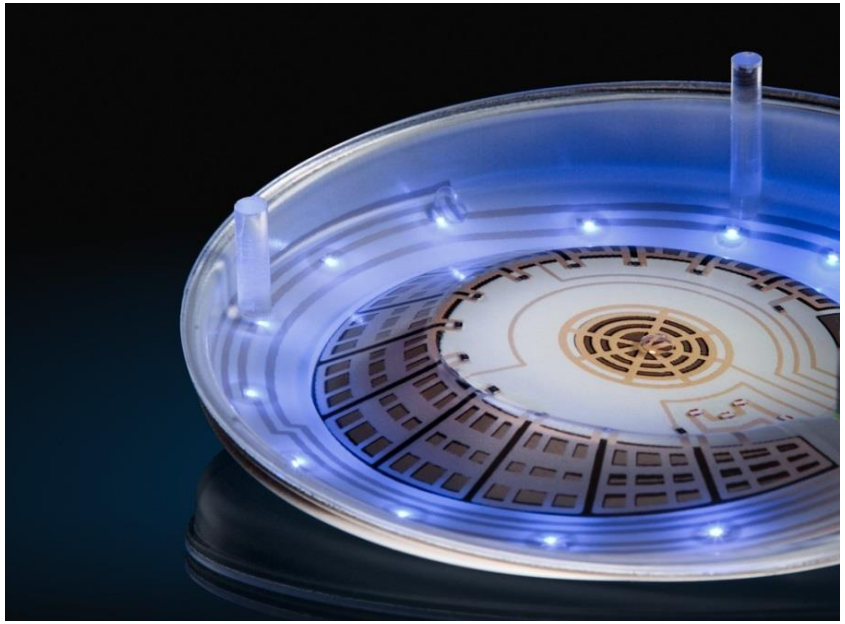






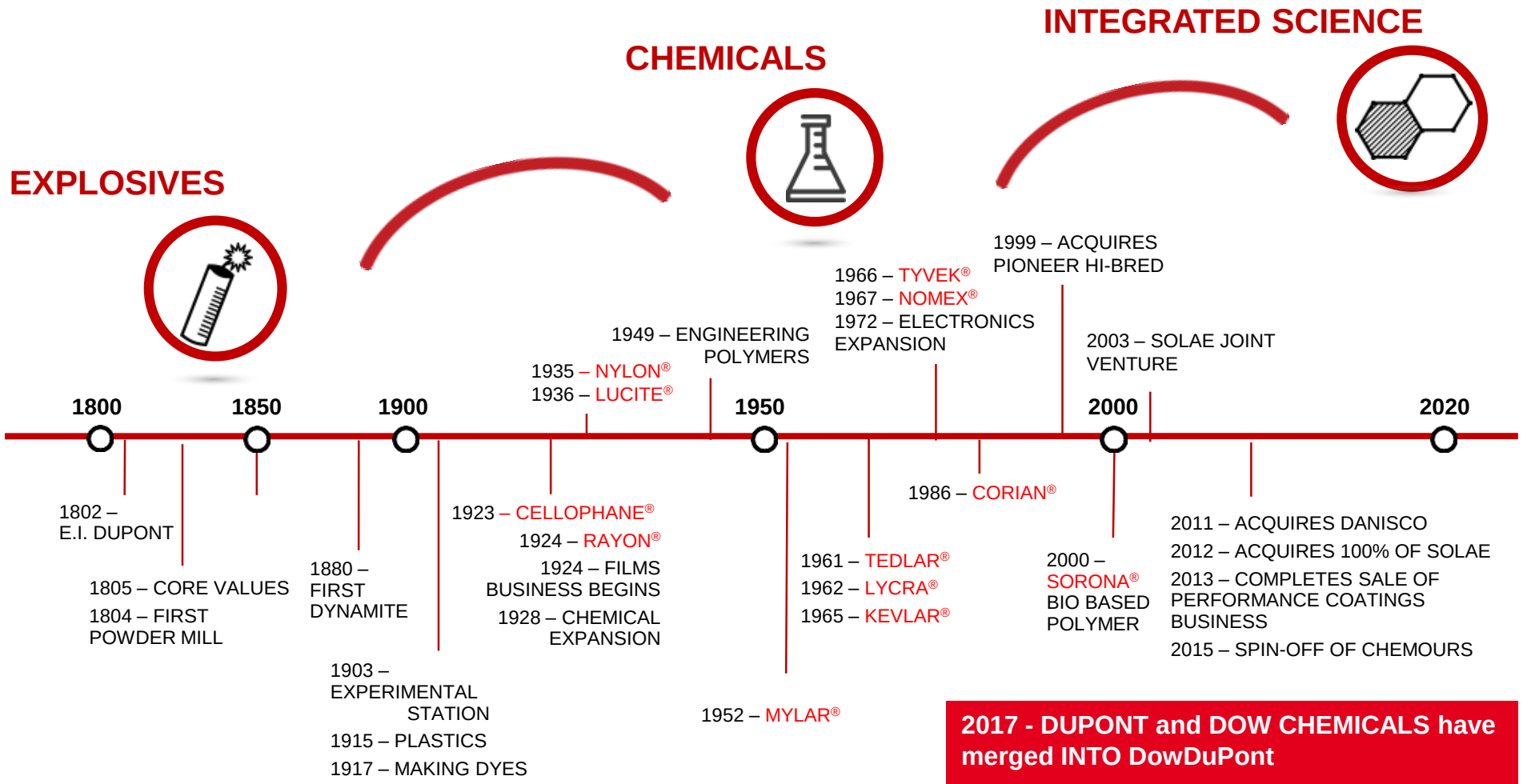
Functional Ink Systems for “In Mold Electronics”

The Next Generation Human-Machine Interfaces

Microcircuit Materials

DUPONT™

DuPont Has Evolved Over Two Centuries



2017 - DUPONT and DOW CHEMICALS have merged INTO DowDuPont

2019 – Split into 3 independent companies

Electronics & Imaging Advanced Materials

Business Development: Science + Market Needs → Innovation

Microcircuit Materials Traditional Business

Over **50 years of experience** in the development, manufacture and sale of specialized "Thick Film Compositions" (Pastes / Inks) for the Printed Electronics Industry

Core Technologies:

Fine Powders

Ceramic Science

Glass Science

Coating Technology

Polymer Science

Photopolymer Technology

Dispersions

Rheology

Tape Casting

Products:

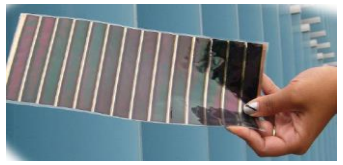
High & Low Temperature Screen Printable Pastes:

- Conductors
- Resistors
- Dielectrics

Major Traditional Applications

Automotive

Photovoltaic



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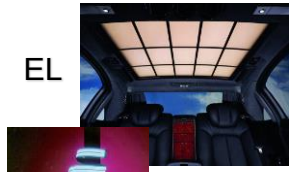
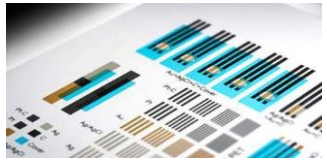


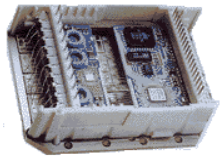
RFID

MTS

Bio-Medical



Power Supply



Automotive Interiors History – Past

Automotive Interiors History – Recent

Automotive Interiors History – Present

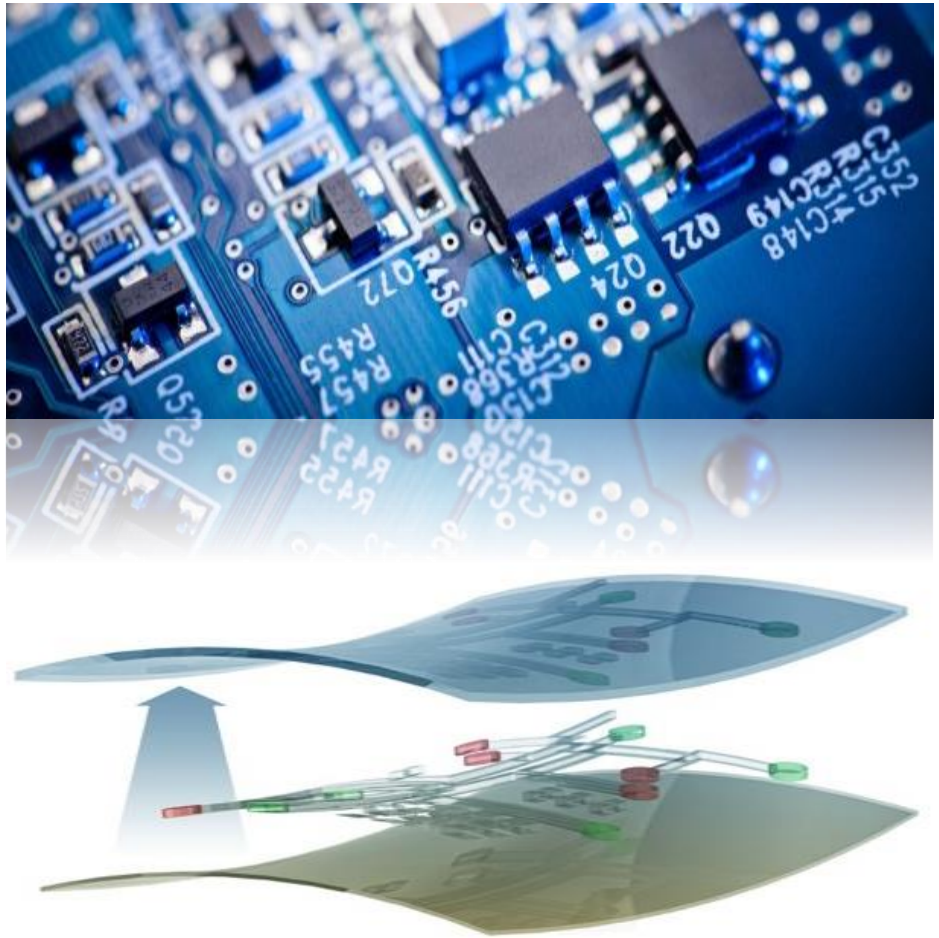
Mechanical Controls

Solid State Controls

Automotive Interiors History – Future

Actually there is however a major limitation:

PCBs are flat & rigid constraining the design options and the intelligent function effectiveness…



What if I could encapsulate intelligence and functionality directly into 3D surfaces?

Example: HMI Control Panel

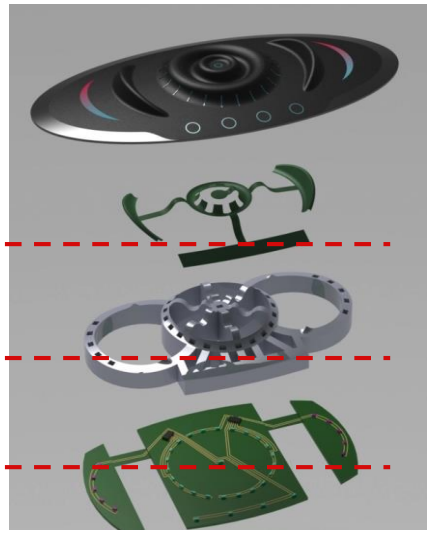
Traditional Design Example

Surface plastics (Foil visual finish and molded plastic)

Flex for capacitive switch

Light pipes

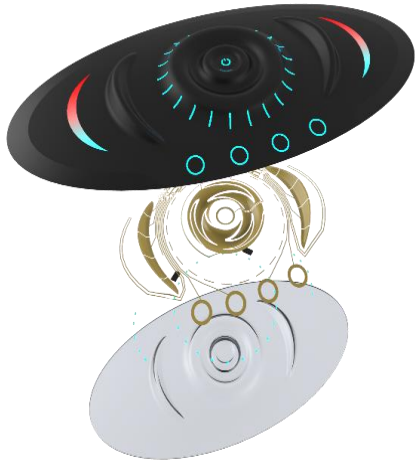
Full width rigid PCB



Design Properties

- Assembly depth: 25+ mm
- Numerous components
- Multiple manual assembly processes
- Complex electrical connections
- Mature technologies

Surface Encapsulated Design Example



Foil with visual finish

Printed circuitry, SMD LEDs and ICs on IML foil

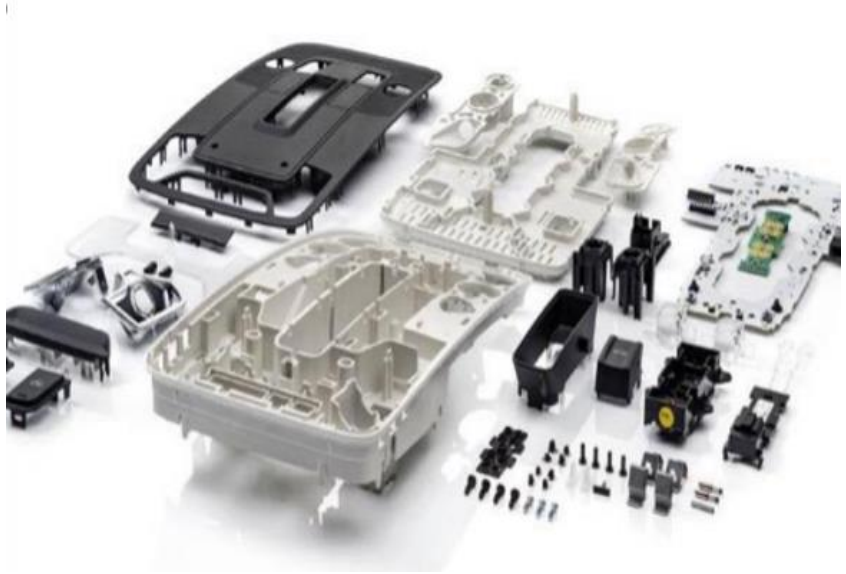
Injection-molded plastic

Design Properties

- Wall thickness: ~3 mm
- 50-70% weight reduction
- Sensors in surface structure
- Environmentally-protected electronics
- Consolidated electrical connections
- Single-component solution

Courtesy of TactoTek

Example: Overhead Console



Before (mechanical button)

After (capacitive touch)

Source: Tactotek

	Conventional assembly	IME version	Differences
Weight	650 g	150 g	77% lighter
Assembly depth	45 mm	3 mm (un-form)	93% less depth
Mechanical parts	64 parts	2	96% less parts
PCBA size (*DP estimate)	10 x 4 cm	10 x 3 cm	25% smaller area

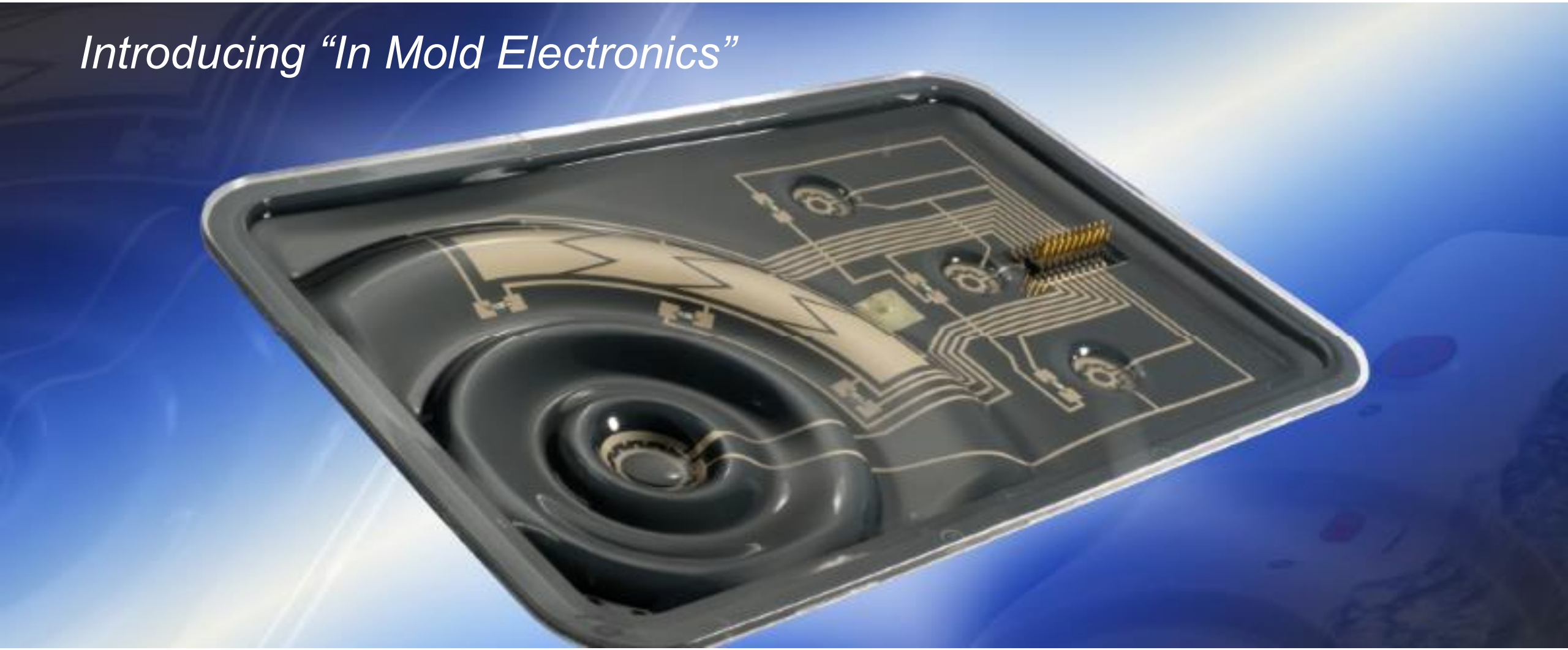
Intelligent Surfaces Potential

Integration of:

- Electronic circuits: Electrical connections, shielding, etc…
- Interfaces: Capacitive switches, curved touch surfaces etc…
- Sensors: Antennas, proximity and gesture detectors, etc…
- Electronic components: LEDs, ICs, etc...
- Screens: OLEDs…?

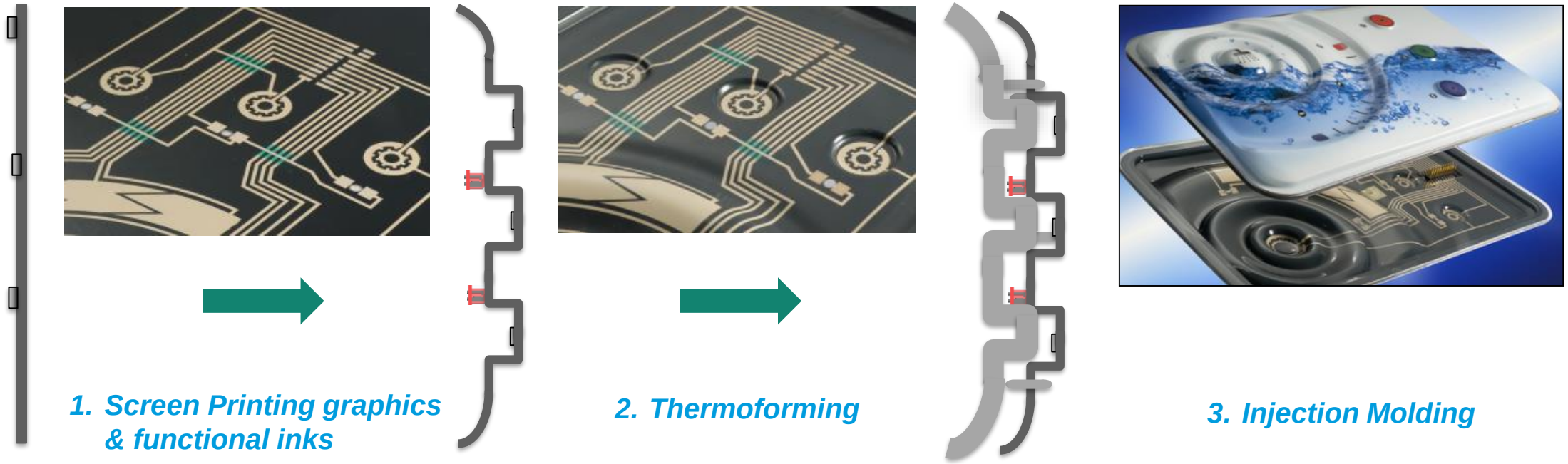
The Ready To Use Solution

Introducing “In Mold Electronics”



IME in 3 Basic Steps

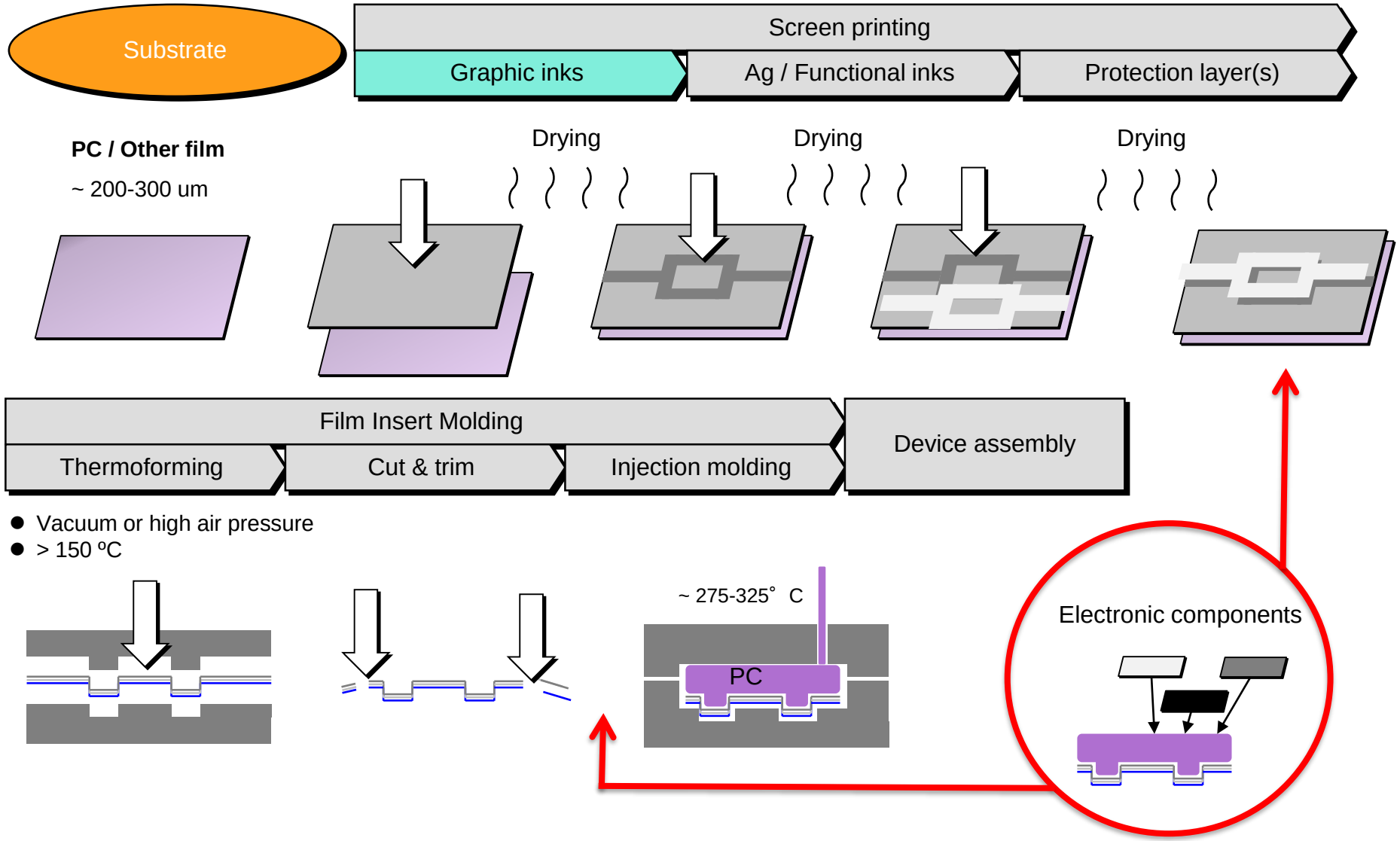
In Mold Electronics refers to Printed Electronic Circuitry on a polymer film substrate which successively undergoes a thermoforming and an injection moulding process. The circuit remains functional as the conducting tracks contour the 3D shape.



1. *Screen Printing graphics & functional inks*
2. *Thermoforming*
3. *Injection Molding*

This technology is an extension and addition to IMD / FIM (In Mold Decoration /Film Insert Moulding) with base technology from the 1990's. It combines films, graphics and electronics to form a 3D aesthetical, functional, fully integrated part

IME – Typical Manufacturing Process



IME Benefits

Versatile technology with features that lead to immediate benefits

Up To 70% Lighter

Elimination of mechanical buttons, sliders and wires.

IME part can be as slim as 2mm thick!

Highly Touch Sensitive

Capacitive switches are printed directly on device surface

New Design Freedom

Enable 3D modern Smart Surfaces design with continuous surfaces

Durability

Injection molded part protects components from vibration and environment

Up To 40% Assembly Time Reduction

Switches, LEDs and components embedded in structure significantly reduced parts for assembly

Up To 30% Less Cost

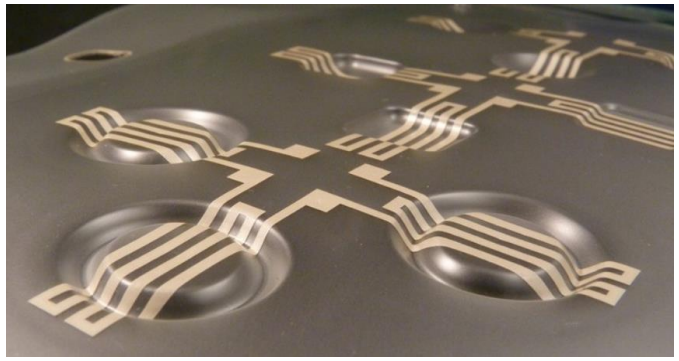
Simpler and more efficient production

Enabling Technology

Why has this not been possible before and how is this achieved now?

Conventional printed electronics Ag Paste

ME602 thermoformable silver ink



Through the developments of new, specially formulated functional inks

Paste / Inks Constituents

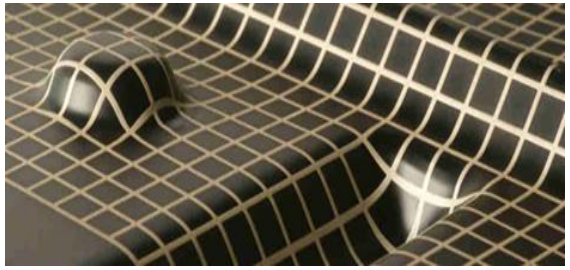
Key elements of a polymeric IME paste composition

Polymer

Elastic / Stretchable
Good adhesion to PC
Withstands high temperatures

Solvent

Solubilises the polymer
Good screen print properties
Compatible with PC & graphic inks



Filler

IME functional ink

Conductor: Ag, Carbon, etc.

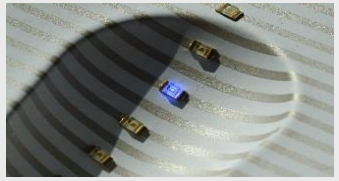
Dielectrics: different for under / over print, cross-over, etc.

- **Compatibility with substrates / graphic inks / and among DuPont IME ink portfolio**
- **Balance of viscosity, good printing properties**
- **Balance for conductivity & ability to stretch**
- **Good adhesion and temperature resistance to withstand "wash out" during injection moulding process**

IME Product Portfolio – Dielectrics

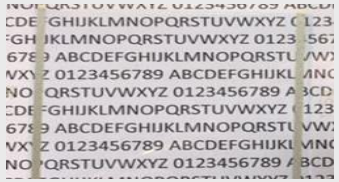
Silver Conductor

ME602 - PC friendly & for over-printing on graphic inks
ME603 - PC compatible & improved Ag show-through
ME101 - For RFID Antenna, NFC enable (reduced elongation)



Conductive Adhesive

ME902 - For attach component, thermoformable, good adhesion



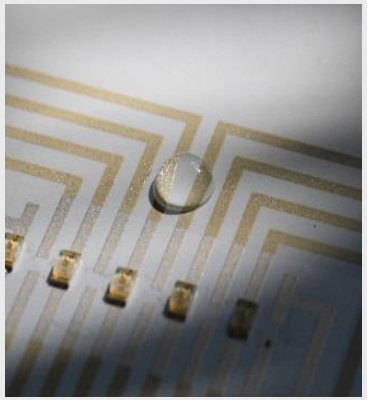
Transparent Conductor

ME801 - Good conductivity, high light transmission >90%

Carbon Conductor

ME201 - Overprint for connectors & to inhibit Ag migration

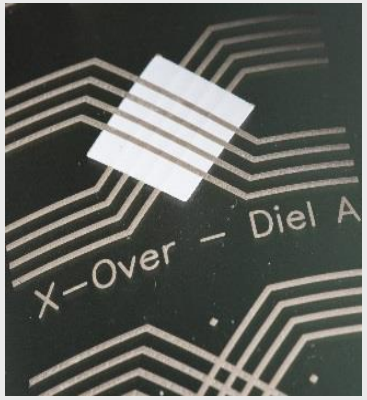
IME Product Portfolio – Dielectrics



Protection Encapsulant

ME772 - White Over-print protection – solvent based

ME780 - Clear Over-print protection – solvent based, good abrasion with UV protection



Crossover Dielectric

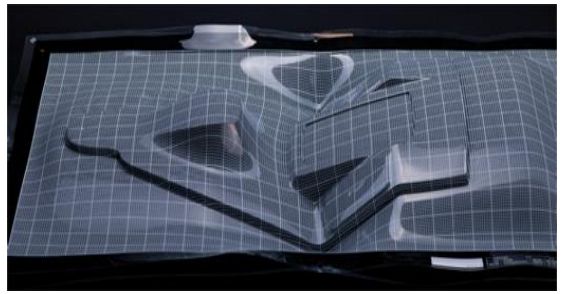
ME778 - Reduced pinhole, stable BDV at elongation

ME779 - Wide process window (oven or belt drier)

DuPont IME Active Collaborations

To provide an IME solution to the Industry - from paste to final functional device - we know there are challenges related to materials and processes:

Collaboration with technology leaders and specialized innovators is therefore essential



Printing
- **Pröll** - Graphic Inks

Thermoforming
- **Niebling** - High Pressure

Solutions & Know-How
- **Various companies** - specializing in IME

Application Development Resource
- **Holst Centre** – Hybrid Printed Electronics cluster
  WP7 Platform (In Mould Electronics)

IME – Summary / Conclusions

- **Versatile technology**
  - In Mold Electronics is ideally suited to quickly develop “intelligent surface” solutions by fitting existing IMD / FIM products and processes
- **Novel dedicated ink technology and complete suite of materials**
  - New functional ink chemistries for conductors, dielectrics, carbons and adhesives complying with the typical IMD / FIM substrates, stretching and thermal / mechanical process conditions
- **Robust and reliable technology and products**
  - Proved environmental test performance and thermal cycling resistance
- **Ongoing technical work**
  - New generation of improved conductors and dielectrics
  - Layers stack up design
  - Generation of additional reliability data

DUPONT™