

Printed Electronics

Sun Chemical/DIC

Advanced Materials Group

SunChemical®

a member of the DIC group



Color & Comfort

working for you.

Outline

**Sun Chemical
Overview**

Printed Electronics

**Market Trends and
Applications**

Value Chain

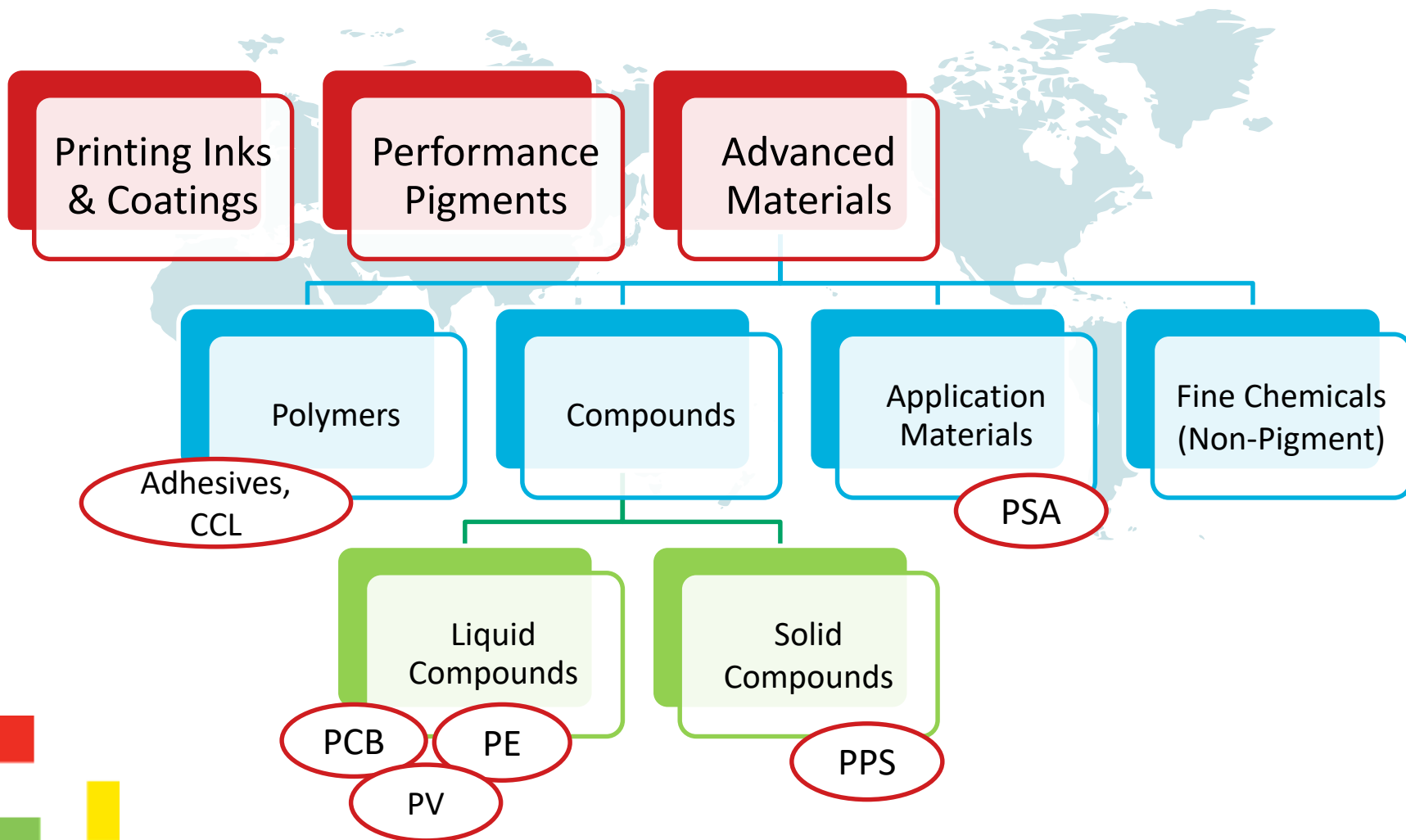
Core Competency

SunChemical®
a member of the DIC group 
Color & Comfort

working for you.

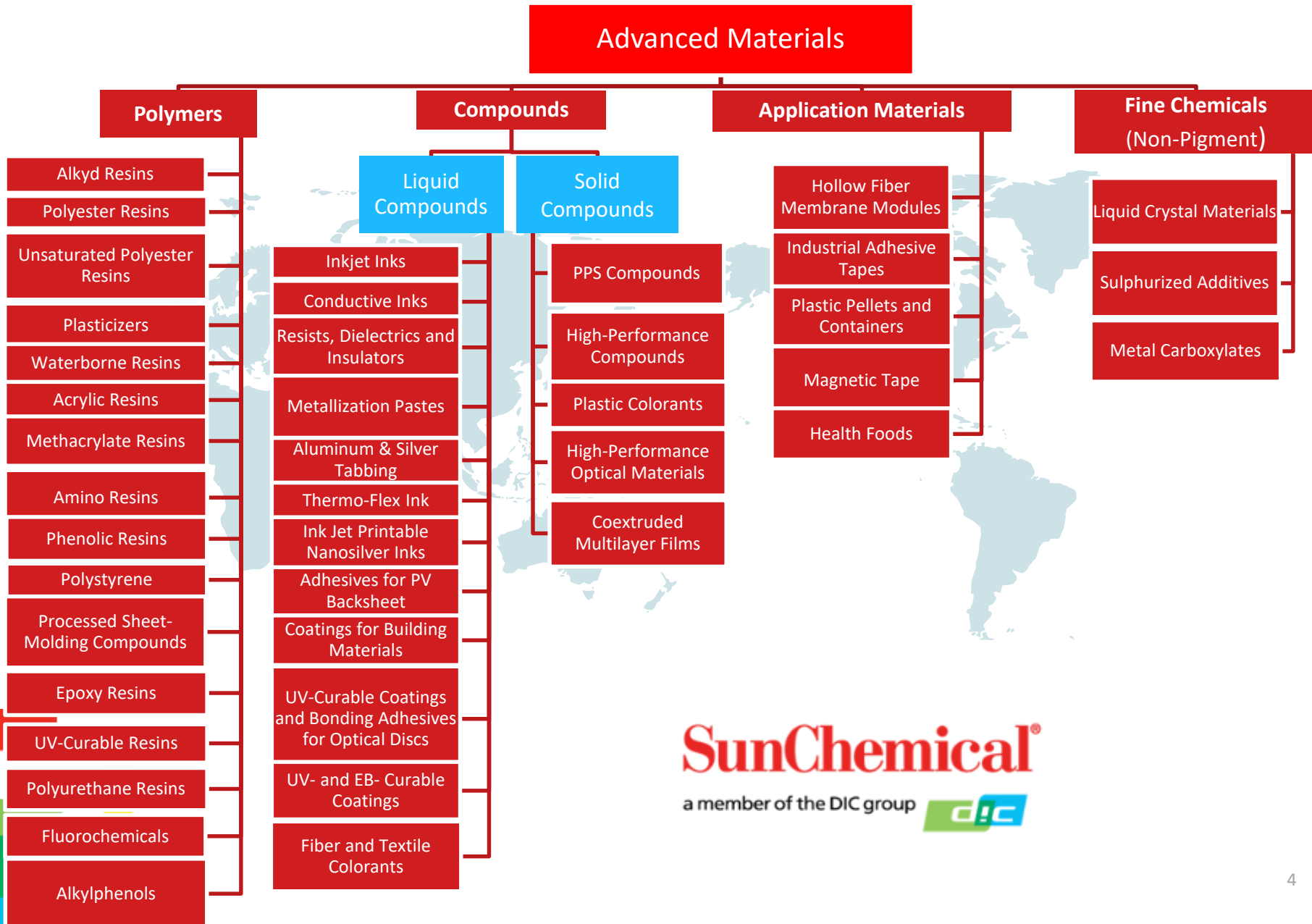
DIC/Sun Chemical Advanced Materials Group

by Product Groups



Sun Chemical's global presence, combined with advanced technologies and products from Sun & DIC, allows for the delivery of local service and support with *Solutions.™* Tailor-Made.

Sun Chemical Advanced Materials Products:



Sun Chemical Electronic Materials

Main Market Segments

- **Inks for Printed Circuit Board**

- Solder mask, etch and plating resists, legend inks, etc.
- Rigid and Flex PCBs



- **Inks for Solar Market**

- Solvent, UV and hot melt plating and etch resists
- Advanced PV technologies



- **Inks for Printed Electronics**

- Conductive and dielectric inks
- Etch resists
- Diverse range of material needs for diverse range of applications





Printed Electronics

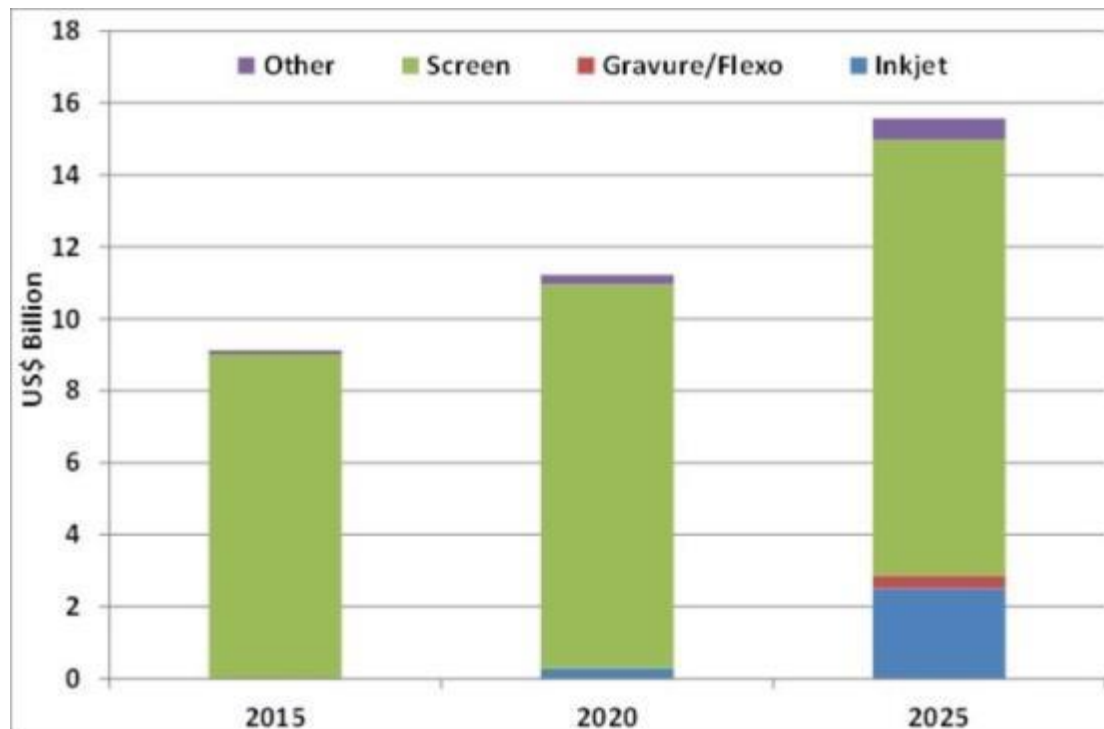
The basic value proposition for printed electronics is that by using **additive processes**, instead of subtractive processes, you can **lower complexity** and **cost of manufacture**.

Markets at different levels of maturity, revenue, profitability and growth

Conductive Ink Market

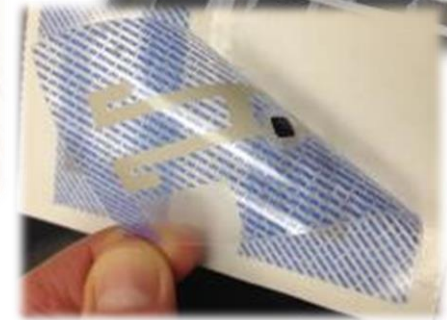
- At about \$2.3 Billion in 2015 – dominated by front side silver paste for solar metallization, followed by printed bezels for touch panels (tablets and phones)
- Overall growth at 3.3% CARG in 2020

total value of printed components split by printing technology type

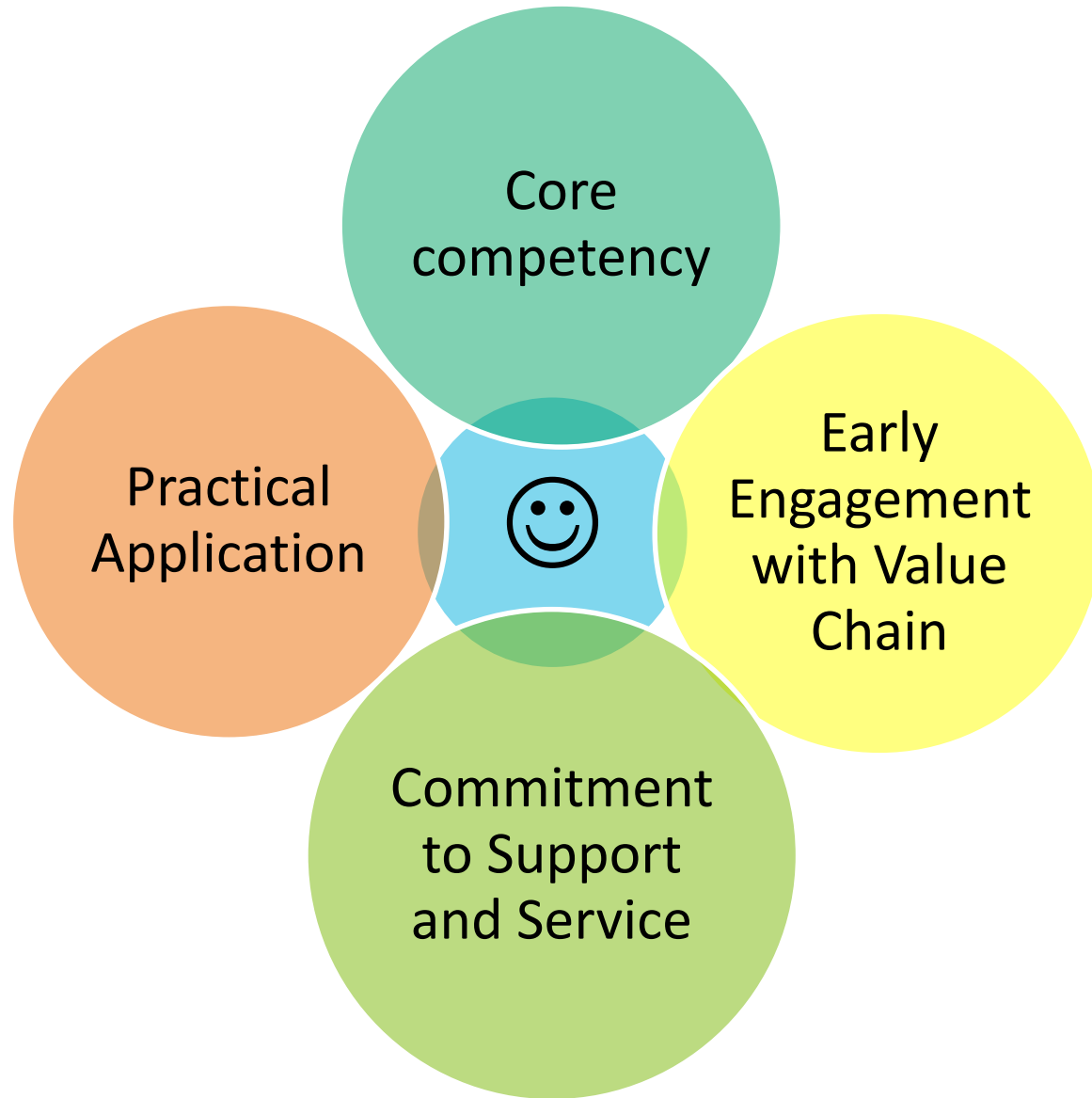


Source: IDTechEx

Printed Electronics Applications

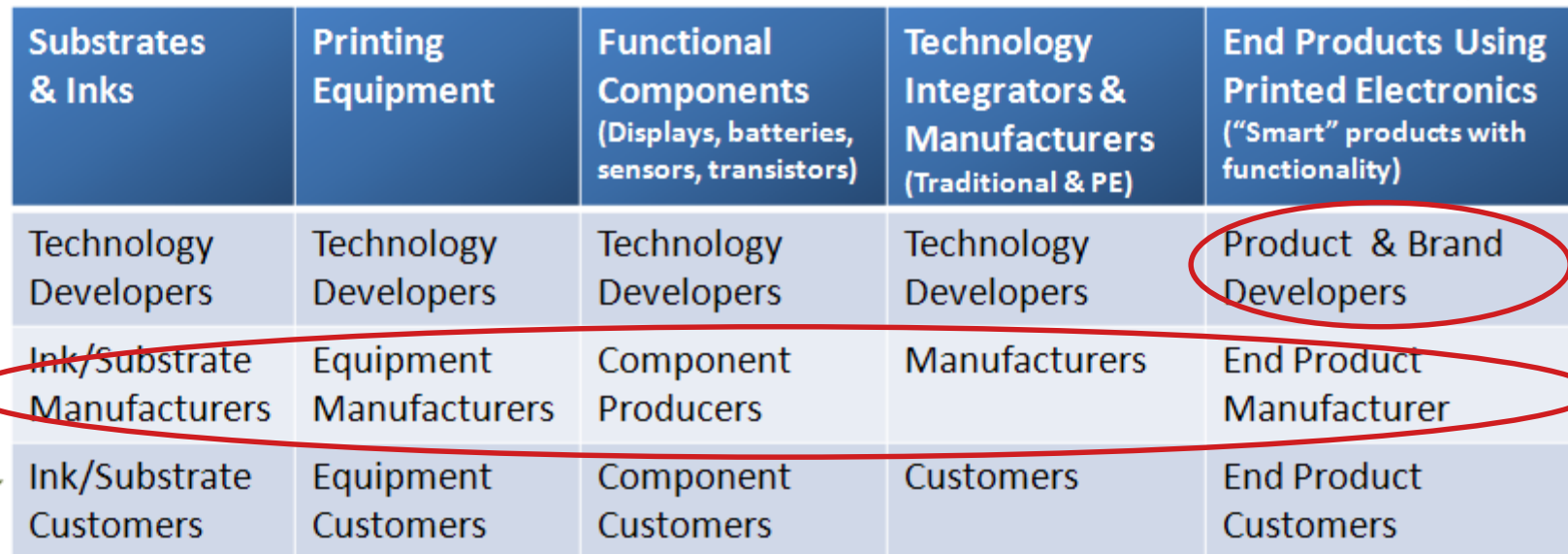


Combination for Success



Printed Electronics Value Chain

Complete Industry Value Chain for the Printed Electronics Industry



Substrates & Inks	Printing Equipment	Functional Components (Displays, batteries, sensors, transistors)	Technology Integrators & Manufacturers (Traditional & PE)	End Products Using Printed Electronics ("Smart" products with functionality)
Technology Developers	Technology Developers	Technology Developers	Technology Developers	Product & Brand Developers
Ink/Substrate Manufacturers	Equipment Manufacturers	Component Producers	Manufacturers	End Product Manufacturer
Ink/Substrate Customers	Equipment Customers	Component Customers	Customers	End Product Customers

Source: <http://www.aistrupconsulting.com>

Sun Chemical brings together key partners in the value chain to lower risk and increase rate of success

Electronics Market trends favoring Printed Electronics

- **Touch Sensing**
 - Touch switches/panels being integrated into everyday devices
- **Structural electronics**
 - Molded interconnects, 3D antenna, In-mold Electronics
- **Tracking, security and identification**
 - High speed printing directly on label or packaging with conductive inks, inventory control
- **Interactivity**
 - Smart packaging and labels with printed sensors, games and toys,
- **Wearable electronics**
 - With sensors integrated directly into textile garments or bands.
- **Energy harvesting and storage**
 - Integrated flexible PVs and printed batteries
- **Internet of Things**
 - Smart homes and cities
 - Connection and communication of everyday devices enabled by printed electronics.

Touch Sensing

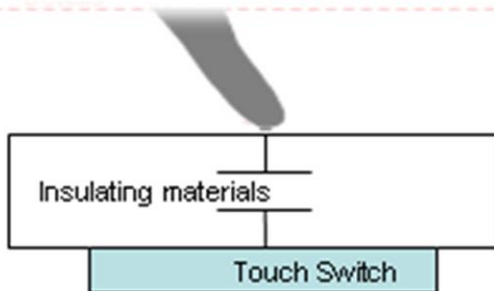
used in devices requiring switches, sliders , scrollers, touchpads, or their combinations

Target Markets

- Appliances
- Consumer electronics
- Automotive
- Industrial controls
- Healthcare

Sun Chemical offers and develop advanced solutions for touch sensing

- conductive and dielectric inks,
- fine line printable silvers for transparent electrodes (50 microns capable)
- nanosilver based inkjet and screen printable for low profile and high conductivity
- DIC's Pressure sensitive adhesives
- Partner with touch sensor technology developers to develop integrated solutions



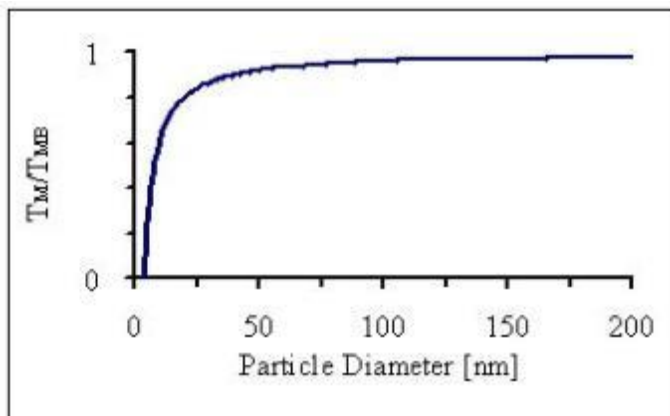
Electric conduction between finger and touch switch creates a field of capacitance that triggers the on/off switch.



Suntronic Nanosilver for Printed Electronics

PROPERTY	EMD5730	EMD5800 and 5805
Silver Content	40%	48-65%
Binder	Solvent-based	Oil-based
Particle Size	50 nm	7 nm
Print Process	Inkjet	Inkjet, aerosol jet, dispense, screen
Volume Resistivity	10 – 30 $\mu\Omega\cdot\text{cm}$	4 – 30 $\mu\Omega\cdot\text{cm}$
Sintering Temperature	150 - 250°C	80 - 150°C

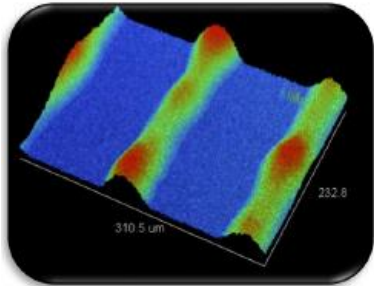
Melt point depression



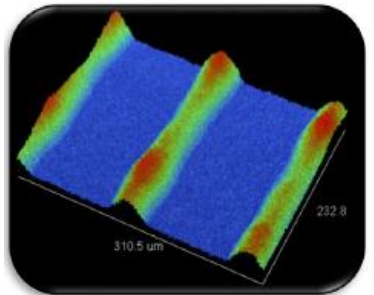
- New nanosilver product line
- Superior conductivity
- Reduced sintering time and temperature
- Digital or high speed roll to roll

Fine line solutions for Touch Sensing

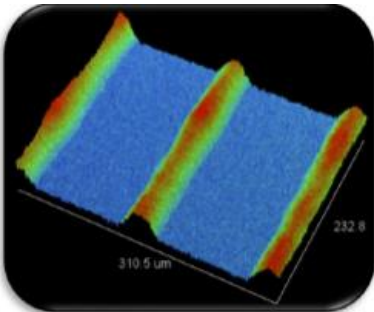
Screen printed nominal
50 micron wide lines
ASADA mesh/WCPC



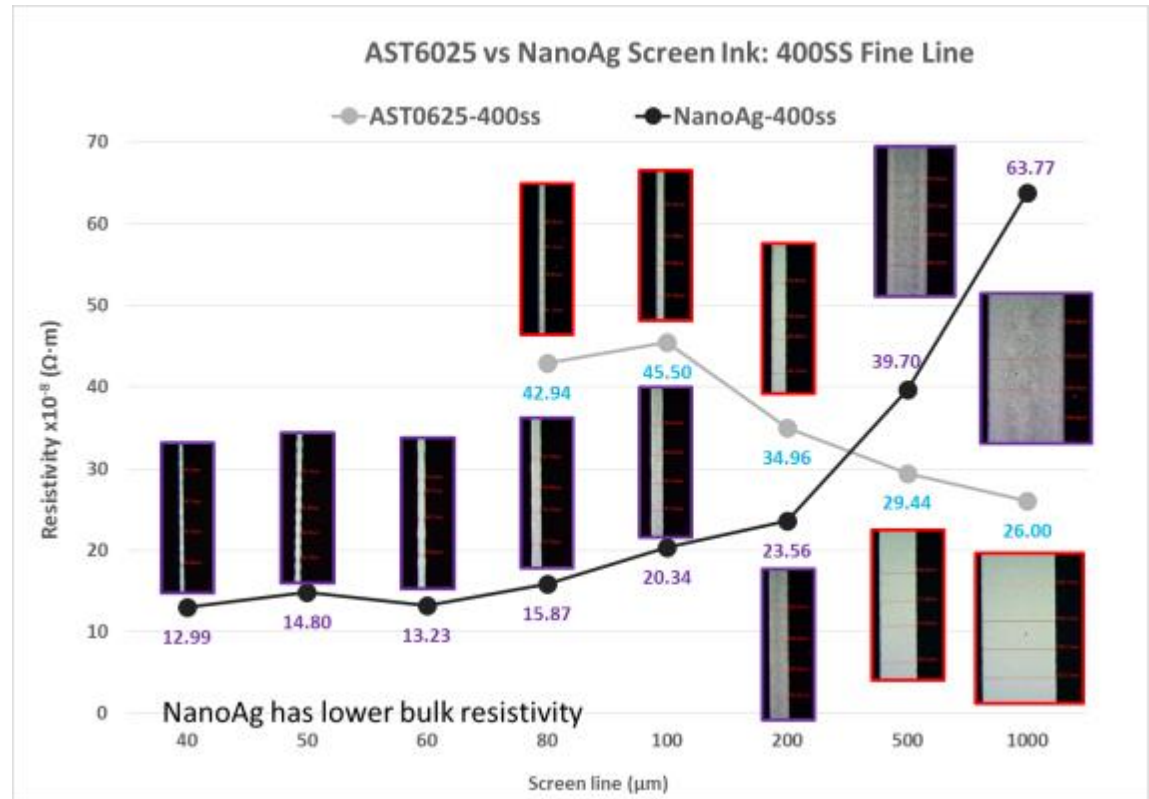
290 mesh
62 microns



400 mesh
56 microns



500 mesh
49 microns

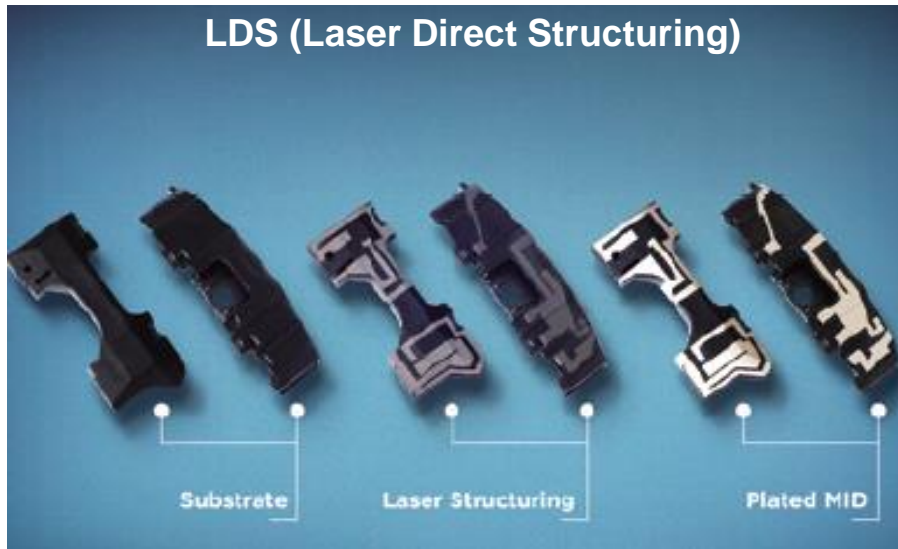


- Considering 100 micron line width: 20 microns thick for AST6025 vs 8 microns thick for nanoAg ink
- Resistivity >50% lower for nanosilver ink
- Same resistance can be achieved with ~5x less thickness

Printed Antenna for Mobile Devices

- Today's mobile devices have higher # of antennas, more complex designs, thinner devices, integrated sensors and other components
- Pressure on time-to-market, cost, supply chain and ease of integration, innovation and differentiation

LDS (Laser Direct Structuring)



- Mature technology
- High performance
- **Design** - restricted materials (mostly ABS, and black), No LDS will image directly on covers or chassis
- **Development** - time consuming – 6h plating step only
- **Production** – complex supply chain and logistics, environmentally not friendly

Printed Antenna

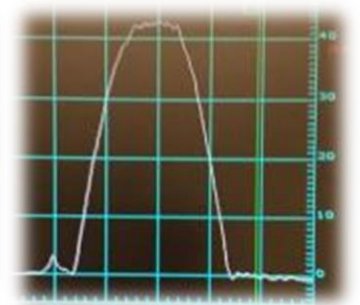
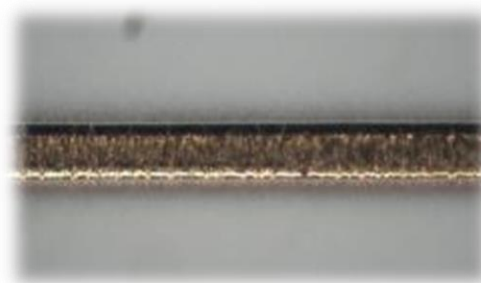


- **Design** freedom - wide range of plastics and colors
- **Development** - Reduced time for prototyping
- **Production** - simplified & environmentally friendly
- In development
- Ease of adaptation?

Direct write methods for additive structuring on 3D parts

Direct patterning on 3D surfaces - fluid development in partnership with
equipment manufacturer

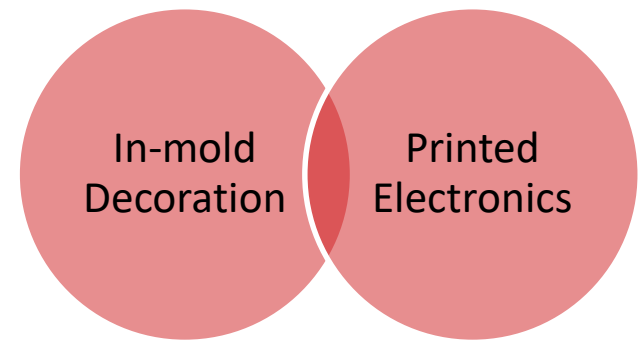
Dispensing



In-mold Electronics (IME)

- More **ergonomic**, thinner parts (no need for dead space), lighter weight (>70% lighter)
- **Less expensive manufacturing** process by replacing wiring with printed traces and printed devices, less raw materials
- **Less assembly**
- **Less moving parts** to fail or wear out
- **Durability**, total encapsulation of printed switches
- More **design freedom**

Highly reliable thermoformable inks that withstand injection molding



Source: Tactotec

Target markets:

- Automotive interiors
- Appliances
- Consumer electronics
- Wearables
- Medical devices

Sun Chemical/DIC Core Competency for IME

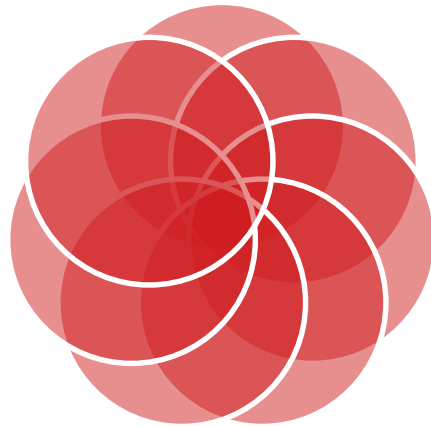
- Sun Chemical is **one of the main suppliers** of graphic inks to IMD for appliances, automotive and packaging applications.
- **Graphic ink product portfolio** includes SB and UV curable thermo-formable and moldable solutions for first and second surface molding.
- **Adhesion promoters** for various molten plastics used in appliances and automotive sectors
- **Strong relationships** with across value chain for IMD
- **IME conductive and dielectric inks** near commercialization
- Combining IMD graphic inks and fully compatible IME electronic materials, **Sun Chemical gains advantage as a full solution provider.**
- Enabling production of fully decorated and multilayer in-mold electronics.

In-mold Electronics Cont'd

IMD/IME ink
supplier

Brands

Molder

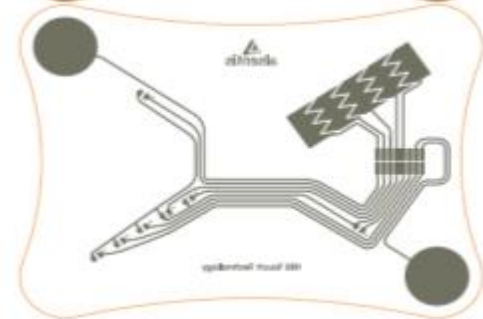
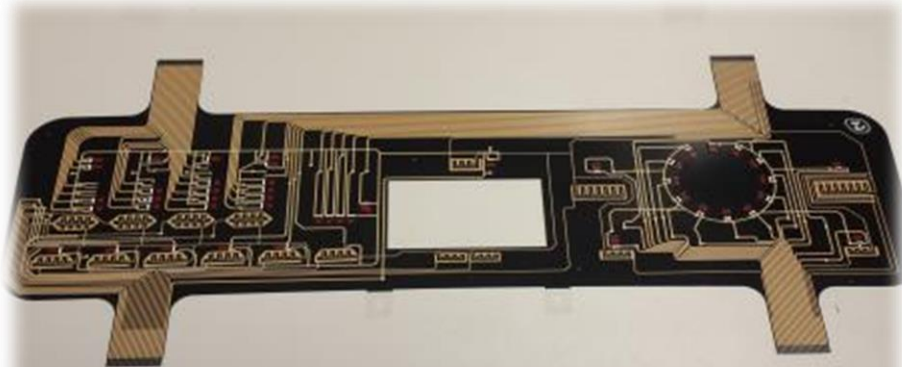


Film supplier

IMD and
Electronics
Printer

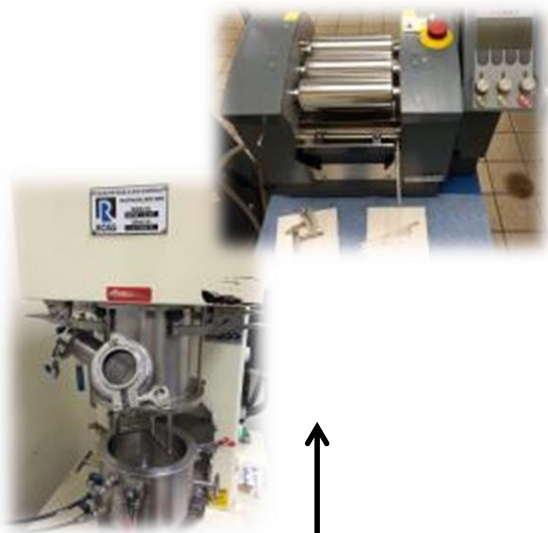
Former

Touch sensor
design

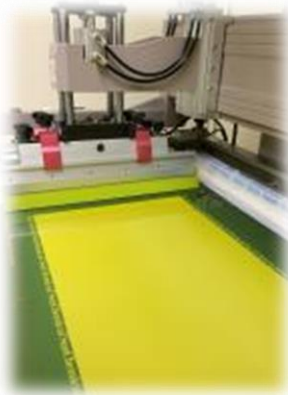


Electronic Materials R&D and Application Development Laboratory

Pastes development & preparation



Screen Printing



Drying/UV curing



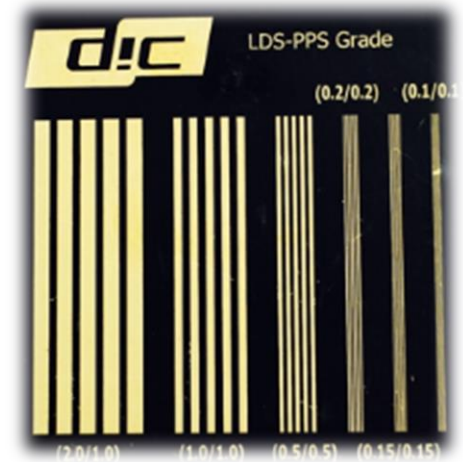
Dry layer testing: environmental characterization, printability, electrical performance characterization, adhesion, flexibility, etc.

Sun Chemical- AMG Electronic Materials Portfolio						
Printing Method	Product Type	Drying/ Curing	Filler	Features	Status	Applications
Flexo	Conductors/ Insulators	Thermal	PTF Silver/ Graphite/ Dielectrics	Waterbased/ UV	Commercial (AMG)	Printed antenna (2D), smart label, Touchcode, RFID
Screen	Conductors/ Insulators	Thermal	PTF Silver/ Graphite/ Dielectrics	Solvent / UV	Commercial (AMG)	RFID, Human Machine Interface, membrane touch switch, circuits
Screen	Conductors/ Insulators	Thermal	PTF Silver/ Dielectrics/ Graphics	Solvent/ UV	Development (AMG)	In-Mold Electronics, switches, circuits
Dispense	Conductors/ Insulators	Thermal	PTF Silver/ Graphite/ Dielectrics/nanosilver	Solvent	Commercial (AMG)	Printed 3D antenna - Pulse
Screen	Etch Resist	Thermal	Dielectric-none	Solvent	Commercial (AMG)	Photovoltaics
Inkjet	Etch Resist	Thermal Freezing	Dielectric-none	Wax	Commercial (AMG)	Photovoltaics
Inkjet	Insulators	UV	Dielectric-none	UV	Commercial (AMG)	Printed antenna, circuits
Inkjet	Conductors	Thermal Photonic	Nanosilver	Oil based/ Solvent based	Commercial (AMG)	Printed conductor, circuits, OPV
Aerosol jet	Conductors	Thermal Photonic	Nanosilver	Oil based	Development (AMG)	Printed 3D antenna, sensors
Screen	Conductors	Thermal Photonic	Nanosilver	Oil based	Development (AMG)	Printed antenna, RFID, circuits, sensors

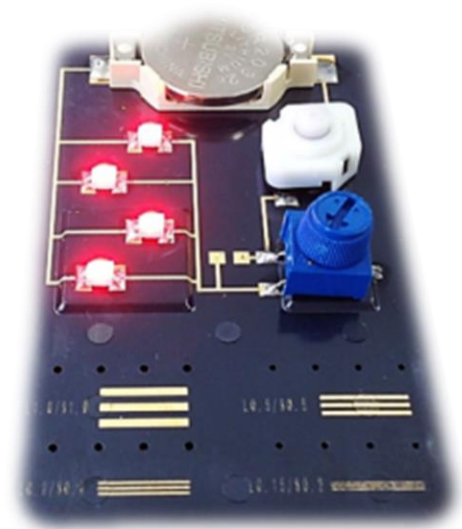


Molded Interconnects

- Laser Direct Structuring is a commonly used MID technology. The 3D circuit carrier is injection molded from a modified compound which allows for laser activation and the successive metallization of the conductor tracks on the surface.
- DIC has recently launched the world's first LDS-PPS resin, which bridges the gap between conventional engineering plastics, such as nylon, to more expensive high-temperature polymers, including LCP or PEEK



Metallized Sample Plate

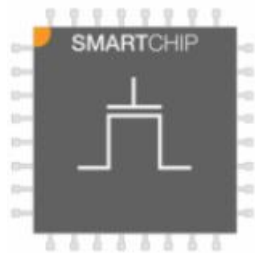


**3D Structured
Electronic Circuit**

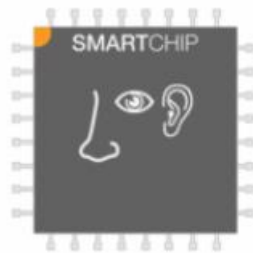
Smart Packaging (interactive and intelligent packaging)

- Enables personalized interaction and information exchange between products and consumers
- **Elements:**

Source: HOLST Centre



Logic



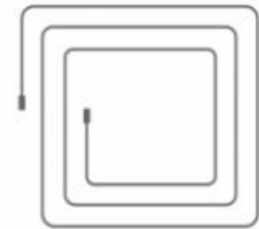
Sensing



Radio



Power



Antenna

Main Applications:

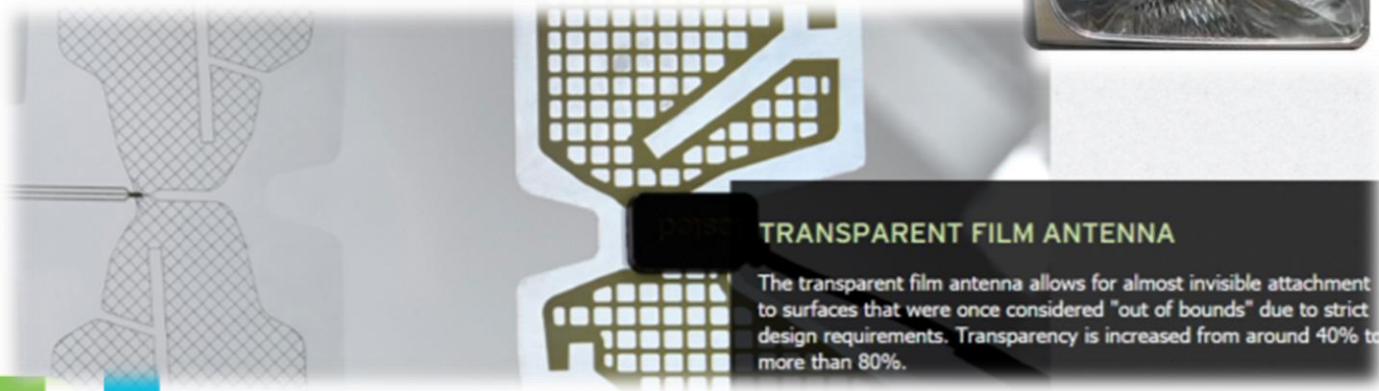
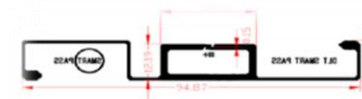
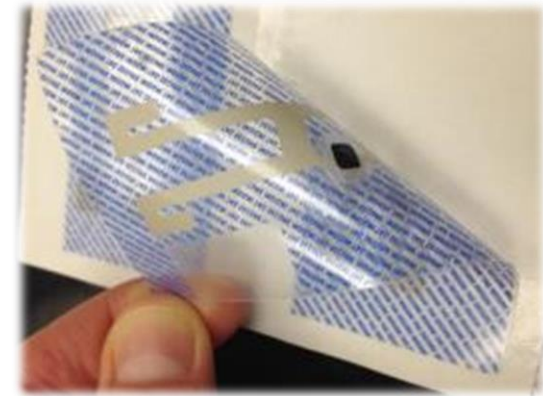
Pharma - provide interaction and prompting, reinforcement and cueing, tracking patient's adherence, send text message reminders, collect data about patient satisfaction, etc.

Food – Active and intelligent packaging

- Food safety in various applications (dairy products, meat and poultry, ready-to-eat meals), Oxygen or ethylene scavengers, moisture absorbers
- Temperature or time monitoring

Smart and Security Labels - RFID

- Smart labels typically use some form of RFID.
- **RFID Labels** - key driver is traceability of an item from manufacture to sale and even beyond.



Smart and Interactive Print at Sun Chemical/DIC

- **Core Competency**

- “the world’s **largest** producer of printing **inks**”
- Expert knowledge of packaging market and liquid inks technologies
- Large customer base from small shops to biggest packaging companies
- We are well established within packaging value chain
- We already have conductive technologies and core knowledge to develop further if application demands

- **Dedicated group for CPG**

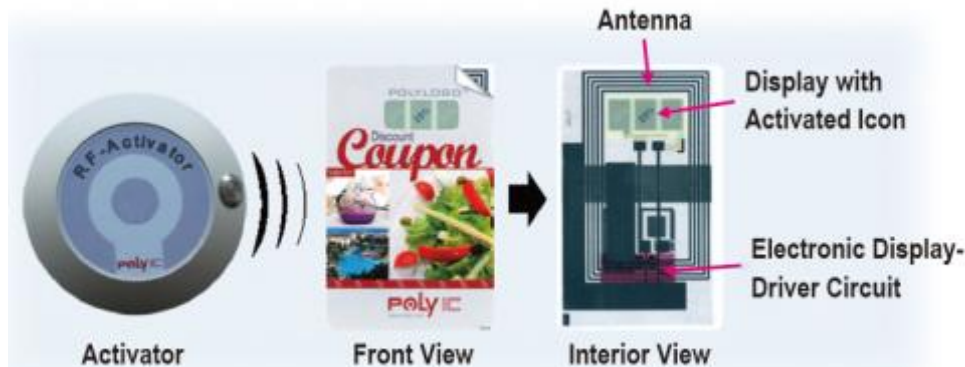
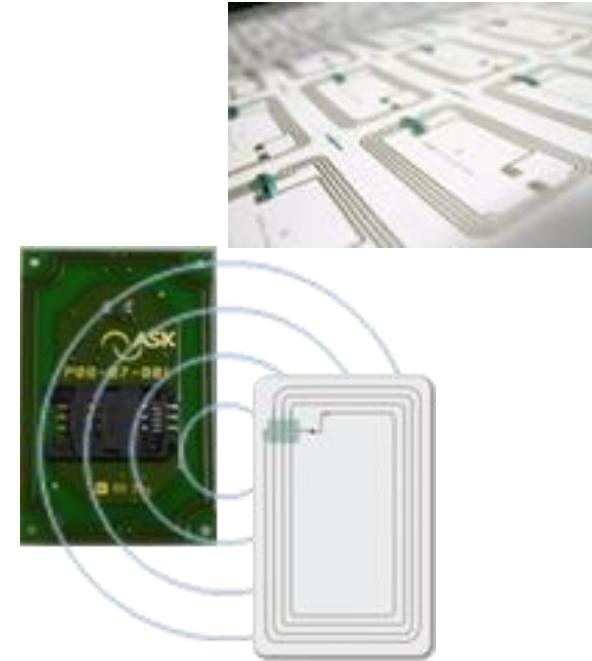
- **Partnering across value chain**

- Main focus on **application development** and integration
 - NFC enabled packaging, wireless communication, printed sensors integration, light up packaging, interactive shelves, wireless power, etc.

Smart Cards – payment, ID, security, transport, ticketing

Contactless cards

- Does not have a battery and instead is powered by the RF wave emitted by the reader.
- The embedded antenna works as an RF power collector.
- The chip is connected to this antenna to receive power and to communicate with the reader.



Sun Chemical/DIC – well established within value chain for plastic cards – supplying graphic inks, conductive inks, mag tape, etc.

Wearable Electronics

- **Smart Clothing and e-Textiles**
 - surge in interest, funding and R&D since 2014
- **Medical and healthcare devices**
 - hearing aids, diabetes management, cardiovascular monitoring, and clinical trial sensors, skin patches, smart bandaids, leak detection sensors, temperature sensors
- **Smart watches, activity and fitness trackers**



Medtronic's Seeq heart monitoring device
Image Source: Medtronic

Stretchable, durable and wash resistant inks, coatings and adhesives



Core Competency

- DIC/Sun Chemical is full solution provider – fully decorated printed electronics
 - Strong foundation in relevant technologies
 - materials for graphics printing, electronics printing, assembly and packaging
 - expertise in ink design, testing and application development
- Continuous investment into R&D and innovation
 - Capabilities internally or through partnerships to design and make prototypes
 - Materials development focusing on new trends
 - Focus on sustainable solutions
 - New revenue opportunities for customers
 - IP development
- Strong presence within value chain
- Strategic partnerships and acquisitions

October 25, 2016

Sun Chemical and the
DIC Corporation
Acquire Gwent
Electronic Materials
Ltd.

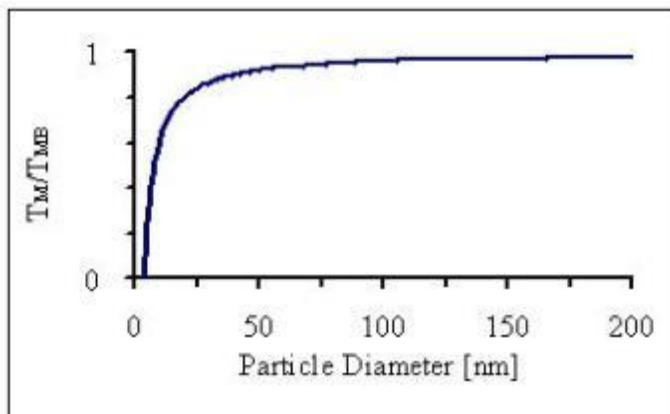
Sun Chemical is a partner that transforms with you

Suntronic Nanosilver for Printed Electronics

PROPERTY	EMD5730	EMD5800 and 5805
Silver Content	40%	48-65%
Binder	Solvent-based	Oil-based
Particle Size	50 nm	7 nm
Print Process	Inkjet	Inkjet, aerosol jet, dispense, screen
Volume Resistivity	10 – 30 $\mu\Omega\cdot\text{cm}$	4 – 30 $\mu\Omega\cdot\text{cm}$
Sintering Temperature	150 - 250°C	80 - 150°C



Melt point depression



- New nanosilver product line
- Superior conductivity
- Reduced sintering time and temperature
- Digital or high speed roll to roll

Our commitment

Quality. Service. Innovation.

Quality

Comprehensive and consistent offering of world-class products, services, and solutions that save time and money.

Service

Our world-class technical and customer service consistently delivers on our promises and collaborates with customers to deliver solutions that solve their unique challenges.

Innovation

With 13 research and development centers, Sun Chemical averages two patents per month with regular breakthroughs in ink, pigment, and application material technology.



Sun Chemical EM Solutions

Technology

Service

Application

Complete Package

**Electronic Materials
and Beyond**

SunChemical®
a member of the DIC group 
Color & Comfort

working for you.