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:

**Advanced Materials**

**Polymers**
- Alkyd Resins
- Polyester Resins
- Unsaturated Polyester Resins
- Plasticizers
- Waterborne Resins
- Acrylic Resins
- Methacrylate Resins
- Amino Resins
- Phenolic Resins
- Polystyrene
- Processed Sheet-Molding Compounds
- Epoxy Resins
- UV-Curable Resins
- Polyurethane Resins
- Fluorochemicals
- Alkylphenols

**Compounds**

**Liquid Compounds**
- Inkjet Inks
- Conductive Inks
- Resists, Dielectrics and Insulators
- Metallization Pastes
- Aluminum & Silver Tabbing
- Thermo-Flex Ink
- Ink Jet Printable Nanosilver Inks
- Adhesives for PV Backsheet
- Coextruded Multilayer Films

**Solid Compounds**
- PPS Compounds
- High-Performance Compounds
- Plastic Colorants
- High-Performance Optical Materials
- Coextruded Multilayer Films

**Application Materials**
- Hollow Fiber Membrane Modules
- Industrial Adhesive Tapes
- Plastic Pellets and Containers
- Magnetic Tape
- Health Foods
- UV- and EB-Curable Coatings
- UV-Curable Coatings and Bonding Adhesives for Optical Discs
- UV- and EB-Curable Coatings
- Fiber and Textile Colorants
- Coextruded Multilayer Films

**Fine Chemicals (Non-Pigment)**
- Liquid Crystal Materials
- Sulphurized Additives
- Metal Carboxylates

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

Source: IDTechEx
Printed Electronics Applications
Combination for Success

- Core competency
- Early engagement with value chain
- Commitment to support and service
- Practical application
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

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

Source: http://kgdisplays.com; http://www.rapidkeypads.com;
Suntronic Nanosilver for Printed Electronics

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

<table>
<thead>
<tr>
<th>PROPERTY</th>
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Melt point depression
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)

- **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

Source: TE Connectivity

Source: www.fluidant.com
Direct patterning on 3D surfaces - fluid development in partnership with equipment manufacturer

Dispensing

Aerosol Jet
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

**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.
<table>
<thead>
<tr>
<th>Printing Method</th>
<th>Product Type</th>
<th>Drying/ Curing</th>
<th>Filler</th>
<th>Features</th>
<th>Status</th>
<th>Applications</th>
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<tr>
<td>Flexo</td>
<td>Conductors/ Insulators</td>
<td>Thermal</td>
<td>PTF Silver/ Graphite/ Dielectrics</td>
<td>Waterbased/ UV</td>
<td>Commercial (AMG)</td>
<td>Printed antenna (2D), smart label, Touchcode, RFID</td>
</tr>
<tr>
<td>Screen</td>
<td>Conductors/ Insulators</td>
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<td>PTF Silver/ Graphite/ Dielectrics</td>
<td>Solvent / UV</td>
<td>Commercial (AMG)</td>
<td>RFID, Human Machine Interface, membrane touch switch, circuits</td>
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<td>Development (AMG)</td>
<td>In-Mold Electronics, switches, circuits</td>
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<tr>
<td>Dispense</td>
<td>Conductors/ Insulators</td>
<td>Thermal</td>
<td>PTF Silver/ Graphite/ Dielectrics/ nanosilver</td>
<td>Solvent</td>
<td>Commercial (AMG)</td>
<td>Printed 3D antenna - Pulse</td>
</tr>
<tr>
<td>Screen</td>
<td>Etch Resist</td>
<td>Thermal</td>
<td>Dielectric-none</td>
<td>Solvent</td>
<td>Commercial (AMG)</td>
<td>Photovoltaics</td>
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<tr>
<td>Inkjet</td>
<td>Etch Resist</td>
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<td>Inkjet</td>
<td>Conductors</td>
<td>Thermal</td>
<td>Nanosilver</td>
<td>Oil based/ Solvent based</td>
<td>Commercial (AMG)</td>
<td>Printed conductor, circuits, OPV</td>
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<td>Aerosol jet</td>
<td>Conductors</td>
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<td>Oil based</td>
<td>Development (AMG)</td>
<td>Printed 3D antenna, sensors</td>
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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.
Smart Packaging (interactive and intelligent packaging)

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

  ![Logic](image1)
  ![Sensing](image2)
  ![Radio](image3)
  ![Power](image4)
  ![Antenna](image5)

**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

Source: HOLST Centre
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.

Source: ASK-RFID, PolyIC

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**

Source: IDTechEx

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

Sun Chemical is a partner that transforms with you

October 25, 2016
Sun Chemical and the DIC Corporation Acquire Gwent Electronic Materials Ltd.
Suntronic Nanosilver for Printed Electronics

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

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Our commitment

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
- Application
- Complete Package
- Service

Electronic Materials and Beyond