working for

Sun Chemical  Advanced Materials Division

Capabilities Presentation to:
HdM Druckerstammtisch  JUN2015

©2012 Sun Chemical.
$7.2 billion net sales
180 subsidiaries and affiliates
20,273 employees in 62 countries

16.5% Neo-Graphic Arts Materials
14.6% Chemical Solution Materials
0.2% Other
20.9% Synthetic Resins
47.8% Printing Ink and Supplies

Color & Comfort by Chemistry
DIC & Sun Chemical History

- 1818: Sun Chemical’s roots begin with Lorilleux, one of the first ink producers
- 1929: Four ink companies merge to form General Printing Inks (GPI)
- 1936: First pigmented flexo inks
- 1945: GPI changes its name and Sun Chemical is born
- 1957: Ansbacher-Siegle merges with Sun Chemical to form today’s Performance Pigments division
- 1958: Development of solvent-based flexo inks on polythelene films
- 1959: Sun Chemical patents first UV inks
- 1969: Sun Chemical acquires Coates and begins offering digital inkjet ink and Electronic inks.
- 1987: DIC acquires Sun Chemical
- 1999: Sun Chemical acquires Benda-Lutz
- 2010: Sun Chemical opens state-of-the-art food packaging plant in Frankfurt and sheetfed ink hub in Dubai, India
- 2012: DIC acquires Sun Chemical
Principal Business Segments

Printing Inks: 51%
Polymers: 16%
Fine Chemicals: 19%
Application Materials: 15%
A stable business since the start

This segment focuses on printing inks, Sun’s mainstay business since its establishment. A global market leader, Sun boasts an extensive product portfolio ranging from publishing inks to inks and adhesives for packaging, enabling it to respond to the needs of customers worldwide.

Offset inks
Gravure inks
Flexo inks
Can coatings
Packaging adhesives
DIC/Sun’s second core business

Capitalizing on DIC’s world-class resin engineering capabilities, this segment provides synthetic resins and resin-related products to a broad array of industries.

**General Polymers**
- Alkyd resins
- Polyester resins
- Unsaturated polyester resins
- Plasticizers
- Waterborne resins
- Acrylic resins
- Methacrylate resins
- Amino resins
- Phenolic resins
- Polystyrene

**Specialty Polymers**
- Epoxy resins
- UV-curable resins
- Polyurethane resins
- Fluorochemicals
Fine Chemicals

- Optronics materials and other high-value-added products

Products in this segment include a wide variety of materials indispensable to digital devices, including LC materials and organic pigments for color filters, which are expected to drive growth in the years ahead.

Organic pigments
LC materials
Alkylphenols
Metal carboxylates
Sulphur chemicals (lubricant additives)
This segment encompasses a diverse range of applied products, including jet inks, engineering plastics and industrial adhesive tapes, made possible by the integration of DIC’s synthesis, dispersion, coating and molding technologies.

**Liquid Compounds**
- Jet inks
- **Electronic Materials**
- Fiber and textile colorings
- Coatings for building materials
- UV-curable coatings and bonding adhesives

**Processed Products**
- Processed SMC products
- Industrial adhesive tapes
- Label stock for printing
- Specialty magnetic foils
- Decorative boards and interior housing products
- Hollow-fiber membrane modules

**Solid Compounds**
- PPS compounds
- High-performance compounds
- Plastic colorants
- High-performance optical materials
- Coextruded multilayer films
Sun Chemical Electronics Materials

Materials and Solutions for Printed and Electronics Applications

- Conductive Inks & Coatings
- Resists, Dielectrics & Insulators
- Solder masks & Circuits consumables
- Graphic Inks & Coatings
- 189 subsidiaries and affiliates in 64 countries and regions

* Figures indicate number of DIC subsidiaries and affiliates in each region
Innovation

Sun Chemical

- Breakthroughs in ink and pigment technology
- 10 R&D centers worldwide
- Averaging two patents per month
R&D Platform: Basic research supports innovation pipeline

- New Product Development
- Technical Service
  - Technical Dept./DIC, Sun and other Subsidiaries
- Objective Basic Research
- New Technology Development
- Basic Research
  - Universities
  - National Projects
  - Kawamura Institute
Ink Technology aligned by the ink delivery process. Teams work closely with customers and suppliers.

<table>
<thead>
<tr>
<th>Support Function</th>
<th>Liquid Ink (SB, WB, EC Flexo &amp; Gravure)</th>
<th>Digital Ink (UV, SB, WB Ink Jet)</th>
<th>Paste Ink (EC offset, SF, CS, HS)</th>
<th>Screen Ink (SB, UV Rotary &amp; Flatbed)</th>
<th>Metal Deco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Coatings</td>
<td>Primers, OPV's Barrier Coatings</td>
<td>OPV's, Primers</td>
<td>OPV's, Primers</td>
<td>OPV's, Primers</td>
<td>OPV's, Primers</td>
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<tr>
<td>Electronic Materials</td>
<td>Conductive &amp; Dielectric Inks</td>
<td>Conductive &amp; Dielectric Inks</td>
<td>Conductive &amp; Dielectric Inks</td>
<td>Etch resists Dielectrics</td>
<td>Dielectric Inks?</td>
</tr>
</tbody>
</table>
Industrial Inks and Coatings

For automotive, electronics, optical disc, plastic card, glass, metal, flooring, furniture, textiles, and more.

- Screen and Pad inks
- Flexo and Gravure inks
- Digital inks
- Energy-Curable inks (UV and EB)
Inkjet Inks

- Energy curable (UV & EB)
- Solvent
- Oil
- Hot Melt
- Aqueous
- Conductive

For graphics, industrial decoration, printed electronics, coding and marking, mailing and addressing, packaging, POP/POS advertising, banners, vehicle graphics, posters, building wraps, etc.
Specialty Coatings

- Coldseal adhesives and release lacquers
- Barrier coatings technology for flexible food packaging
- Antimist coatings
- Heatseal lacquers
- Metal primers
- Aluminum coatings
- Glass coatings
Electronic Materials

For printed circuit boards, solar cells, printed electronics

- Solder masks, dielectrics and marking inks
- Etch and plating resists
- Conductive Inks
- Silver & aluminum metallization pastes
- Inkjet conductive nano Inks and resists
Sun Chemical Circuits

- 50 years in PCB market (inks & consumables)
- A broad range of screen printable products:
  - Solder Masks
  - Via/hole Plugs
  - Plating & Etch Resists
  - Conductive & Dielectric Inks
  - Notation Inks
  - Liquid Polyimides
  - Inkjet Notation Inks

A leader in Liquid Photo Imageable Solder Masks (LPISM) & Resists
Sun Chemical Advanced Materials Strategy

- Leverage knowledge of advanced material technologies in Pigments, Inks, Printing Technology, and Electronics
- Focus on Materials for Printed Electronics
  - Photovoltaics: c-Si & Thin Film oPV
  - Printed Antenna
  - Switches & Sensors
  - Touch Panels
  - Display
  - Display with Touch Screen
  - Lighting
  - E-Packaging / Smart Labels
Basic Conductive Inks

- Based on precious metals
  - Gold
  - Silver
  - Platinum
  - Copper

- Typically use high levels of metal >60%
- Precious metals used due to lack of oxidation

- Based on carbon
  - Graphite
- Typically uses graphite at 50% loading
Basic Conductive Inks

Curing Technology / Resin binder
- Usually solvent based technology
- UV curing technology available
- Thermoplastic or thermosetting resins
- Usually fully cured by high temperatures

Characteristics of Conductive Inks
- Heat generally improves conductivity
- Wide formulating parameters
- Wide adhesion range of substrates
  - Polyester, Polycarbonate, Paper, Phenolic, Epoxy
- Solderable
- Gold and Gold/Nickel plateable
Basic Conductive Inks

- Typical properties of conductive inks:
  - Mesh counts 70 – 100 threads per cm
  - Filmweight 15 microns a standard
  - Resistivity
    - Silver <0.02 ohms per square
    - Carbon <35 ohms per square
  - Hardness of 3H to 5H
Types of functional PE Inks (electrical only)

- Conductive Inks
- NON-conductives - Insulators or Dielectrics
- Organic conductors
- Organic semi-conductors
- Electroluminescent materials
Special functional Inks (tactile & more)

SunInspire Metallics
Emphasizing luxury, worth and value – the Sun Chemical silver, bronze and gold metallic range of inks and coatings provide packaging differentiation and surface appeal to any pack. From matt effect finishes to high brilliance, mirror solutions, Sun Chemical has a complete portfolio of metallic effect inks and coatings.

SunInspire Tactile
With the growth in development of sensory packaging solutions, Sun Chemical has developed a wide range of haptic or tactile coatings to meet a myriad of “touch” requirements. From coarse and gritty to soft or paper feel, bespoke coatings also can be developed for a range of print technologies (flexo, gravure, offset and screen).

SunInspire Lustre
For a touch of light, a gentle movement, a soft design – Sun Chemical lustre effects provide the shimmering, colour change effect required by a wide range of packaged goods providers. From pearlescent to glossy effects, from frosted to iridescent – a broad portfolio of inspiring effects to delight the consumer.

SunInspire Unique
New packaging developments are moving from sensory to interactive designs. First concepts from Sun Chemical include printed optical effects as well as colour change Thermochromic solutions, which react to temperature change intermittently or permanently. In addition, scratch on and off effects, as well as a range of aroma containing inks and coatings to entrance the consumer.

SunInspire Impact
To drive shelf stand out, a range of glowing, bright, startling effects for product promotions and seasonal stories – fluorescent, phosphorescent, sparkle and photochromic effects lift the pack design and shout out the message.

SunGuard Brand Protection Solutions
Not only do special effect inks add differentiation and enhancement to packs but they can also be used as overt and covert ink systems to be used in a multi-layered approach to protect packaging or labels from counterfeit.
Sun Chemical’s complementary SunGuard range is not just ink, but solutions, innovation, peace of mind and confidence in ensuring product and brand integrity.
Materials and Solutions for Printed Electronics Applications

- **Conductive Inks**: various PTF Silvers and Graphite/Carbon Inks
- **Resists**: Etch & Plating Resist for protection while processing,
- **Dielectrics and Insulators**: UV Over coatings (non-conductive)
- Graphic Inks & Coatings: for Supplement only
All commercial manufacturing sites are ISO 9001:2008 Certified
Sun Chemical Electronic Materials Product Lines

SunTronic™

Solsys
- PV: Thin Film Materials
  - CIGS
  - CdTe
  - OPV
  - DSC
  - HIT

Cellmet
- PV: c-Si Materials
  - IBC
  - Selective Emitter
  - PERC

Eclipse
- Printed Electronics
  - Antennae
  - Switches
  - Sensors
  - Lighting
  - Display
  - Touch
  - “Smart” Labels & Packaging
Product Application: Membrane Switches & Sensors

- SunTronic™ Series silver and graphite, printable conductive inks
- SunTronic™ Series dielectrics
- Sun Chemical graphic ink
- DIC coated tape and adhesives
Packaging solution RFID
Product Application: Printed Antenna

- SunTronic™ Series silver and graphite, printable conductive inks
- SunTronic™ Series dielectrics
- Sun Chemical graphic ink
- DIC coated tape and adhesives
MANUFACTURING of RF - ANTENNAS

- Screen Printed Silver Ink
- Gravure or Flexo Silver DIGITAL IJ
- Conductive SILVER OR ETCH RESIST on any printing step
- Etched Copper Foil
- Etched Aluminium Foil
Product Application: Display & Touch Panel

- SunTronic™ Series silver and graphite printable conductive inks
- SunTronic™ Series dielectrics
- Sun Chemical graphic ink
- DIC coated tape and adhesives
- DIC fluorochemical based coatings
- Optical boundary coatings (black, white)
Printed Resistors - Printed Electronic Applications cont.

- Carbon conductive inks form simple ‘resistors’
- Variation in the ink formulation can vary the resistance
- Variation in the print can vary the resistance
- Simple resistors can be used as part of a ‘printed circuit’
- Larger areas can be used as heating elements
- More complex uses are also possible (PTC)
  Positive Temperature Coefficient
  - A form of printed carbon resistor
  - Ink film heats up to a defined temperature and then stops
  - Used in heated car mirror applications
  - Heated clothing?
Print resistors that vary in resistance according to their environment or other factors

These devices are known as Polymer Hybrids (WE, Pforzheim)

The cost is relatively low and they are often disposable

For example an increase in
  - temperature to be ‘measured’
  - mechanical piezo sensor to measure forces / bending
- Biological sensors
  - Blood Sugar
  - DNA testing
  - Alcohol
- Mechanical sensors in automotive
  - Temperature
  - Pressure
  - body sensor (airbag, child seat)
- Automotive sensors for
  - Occupant Classification Safety
  - Orientation Detection, child seat presence
- Chemical sensors
  - pH
  - Organo phosphate (Pesticides in water)
  - Chlorine
Transparent Conductors PE cont.

- **Get in touch: Material Clevios™ PEDOT:PSS** for example, enables backlight switch surfaces

- The touch slider consists of two key elements:
  - The first is a capacitive switch, which handles the actual on / off function.
  - The second element is a kind of 3-D capacitive slider, which consists of numerous, connected in series, switches take over the on / off function of the design typical blue light and driving the control signal device.

*PEDOT:PSS is a polymer mixture of two ionomers.*
Advanced Conductive Inks; Organic Conductors

- Conductive polymer coatings
- Conductive polymer inks
- Conductive adhesives
- Conductive Pre-coated glas / films / substrates
  - ITO (Indium Tin Oxide) coated
- Semi conductive polymer products
- Electroluminescent polymers
- Ultimate aim to replace conductive metal products
Advanced Conductive Inks; PV solar cell

- Silicon Based
  - Silicon Wafer Based
    - Monocrystalline
    - Polycrystalline
    - Amorphous (a-Si)
    - Tandem a-Si / Si Crystalline
    - Thin Film Si Crystalline
      - CIS / CIGS
      - CdTe
      - GaInP₂ / GaAs
      - InGap / InGaAs / Ge
      - Liquid electrolyte
      - Jelly electrolyte
      - Solid electrolyte
      - Polymer - Polymer
      - Polymer - Fullerene
      - Polymer - Inorganic
  - Thin films
- Chemical compound Based
  - II VI
  - III V
    - Dye Sensitized
      - Full Organic
      - Hybrid
- New Materials
Advanced Conductive Inks; PV solar cell

Si-cell

picture by kind permission of ECN, NL
Advanced Conductive Inks; Thinfilm solar cell (TF)
Advanced Conductive Inks; Organic solar cell (oPV)

Layer stack of the inkjet printed tandem device

picture by kind permission of Solliance ECN, NL
Advanced Conductive Inks; Organic solar cell (oPV)

6. Summary

→ Demonstration of the possibility to print every single layer of an OPV module with an inkjet without major losses

→ Freedom of shape makes it possible to print optimized grid structures as well as customized devices
Printed Electronic Applications ff.
Sun Chemical Partners with T+ink and Forms T+sun to Provide Conductive Ink Solutions for Packages and More

PARSIPPANY, N.J., USA – March 20, 2014 – Sun Chemical has teamed up with T+ink to form T+sun, an organization which will provide conductive ink solutions to make packages and objects communicate, engage customers and manage inventory systems.

Drawing from the global resources of Sun Chemical, including the company’s electronic materials, packaging and brand protection groups, T+sun will utilize Sun Chemical’s global R&D, technical support, manufacturing infrastructure, supply chain, marketing, and sales.

T+ink, one of the first emerging companies to commercialize true printed electronics across a variety of industries, including toys, packaging, promotional products, construction and apparel, brings patented technologies that are designed to replace switches, wires, buttons, speakers, lights, sensors, microphones, antennas and batteries with printed ink for touch and motion-activated applications.

“T+ink’s technology creates a dynamic opportunity for our customers,” said Felipe Mellado, Chief Marketing Officer, Sun Chemical. “The innovation we provide through our own research and development, and through strategic partnerships with T+ink and others, can give our customers a complete solution that enables best-in-class packaging designs worldwide now and in the future.”

T+ink. “T+sun will provide a fundamentally new way for brands to communicate, engage consumers, manage inventory and more. Conductive ink replaces RFID codes at a fraction of the cost and offers more security than QR codes.”
HOW DOES IT WORK?

Hold smartphone in hand and open corresponding application (native App or Web-App).

Hold Touchcode card and place it on the multitouch screen. The Touchcode is decoded by the app and content accesses are enabled.
PE Applications cont. Others

- Solar Cells / Photovoltaic
- Shielding (e.g. Electrostatic, EMI, RF)
- Displays with Liquid Chrystal polymers
- Medical Diagnostic devices
- Printed batteries / power devices
Over 30 Year’s Experience
  - All types of print heads
  - Most advances in recent years have been with Piezo DOD

Many Different Applications:
  - Wide Format Graphics
  - Packaging
  - Commercial Print/Publishing
  - Industrial Decoration, Décor,
  - Security / ID
  - Printed Electronics, Photovoltaic's
Partnerships – core to ink jet business

- Sun Chemical EM
- Print Head
- Integrator
- End User
Partnerships – core to ink jet business
Ink Development with Piezo Print Head Manufacturers

- Brother
- Dimatix / Spectra
- Epson
- Konica Minolta
- Kyocera
- Panasonic
- Ricoh
- Sharp
- SII Printek
- Toshiba Tec
- Trident
- Xaar
- Xerox

* = Not Commercialised
Ink Development with Independent Technology Integrators

- Ardeje
- Ceradrop
- FDTI (Fujifilm Dimatix Integration arm)
- FFEI
- HiJet / Megnajet
- Impika
- Inca (Dainippon Screen)
- Industrial Ink Jet IIJ (KM)
- Integrity
- IST / Dip-Tech
- Notion Systems
- Schmid The Technology Partnership
- Roth and Rau
- ToJet
A wide range of inks for Photovoltaic and Printed Electronics

- **EMD 4000** High Temperature Curing Conductive Inks
- **EMD 5000** Low Temperature Curing Conductive Inks
- **EMD 6000** UV Curing Insulators
- **EMD 9000** Hot Melt Etch Resists

- Many bespoke inks for individual applications.
  - Printers, Printheads, Substrates and Final Properties
Jetting and Printing Capability

In Addition to Jetting Rigs for all major printheads
We have available for printing of functional fluids:

- DMP-2831 Inkjet
- Optomec M3D aerosol jet
- OTB Pixdro LP50 Printer
# SunTronic PTF Ag portfolio / product selector [extract]

<table>
<thead>
<tr>
<th>Product ID</th>
<th>Application method</th>
<th>Sheet resistivity, mΩ/μm</th>
<th>Cure Schedule</th>
<th>Resolution</th>
<th>Screen mesh</th>
<th>Printed thickness, μm</th>
<th>Thinner</th>
<th>Cleaner</th>
<th>Substrates</th>
<th>Application</th>
<th>Shelf Life, months</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST6010</td>
<td>Screen</td>
<td>8-10</td>
<td>120-200°C 2-30 min</td>
<td>50 μm</td>
<td>255-420</td>
<td>4-16</td>
<td>ER-SOLV06</td>
<td>ER-SOLV06</td>
<td>PET, TCO</td>
<td>CIGS, CIS, HIT, printed antennae, touchscreen, other</td>
<td>6</td>
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<tr>
<td>AST6000</td>
<td>Screen</td>
<td>15-20</td>
<td>120-200°C 2-30 min</td>
<td>100 μm</td>
<td>330-700</td>
<td>10-16</td>
<td>ER-SOLV04</td>
<td>ER-SOLV04</td>
<td>PET, TCO</td>
<td>printed antennae, membrane switch, flexible circuits, sensors, smart packaging</td>
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<td>120°C 5 min 2-30 min</td>
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<td>255-420</td>
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<td>ER-SOLV11</td>
<td>ER-SOLV11</td>
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<td>PET, PI, PVC, ABS, PCB, card</td>
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<td>50-100 μm</td>
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<td>ER-SOLV14</td>
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<td>PET, PI, PVC, ABS, PCB, card</td>
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<td>AFT6700</td>
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<td>15-20</td>
<td>100-150°C &lt;2 min</td>
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<td>NA</td>
<td>NA</td>
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<td>water / alk.</td>
<td>PET, TCO</td>
<td>Solvent-based nanoparticle inkjet inks for printed electronics and related applications</td>
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<tr>
<td>APT6003</td>
<td>Flexo</td>
<td>15-20</td>
<td>90-150°C 60 min</td>
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<td>water / alk.</td>
<td>PET, TCO</td>
<td>Solvent-based nanoparticle inkjet inks for printed electronics and related applications</td>
<td>6</td>
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<tr>
<td>EMD5730</td>
<td>Padprinting</td>
<td>50-100 μm</td>
<td>150-300°C 30 min</td>
<td>50-100 μm</td>
<td>50-100 μm</td>
<td>NA</td>
<td>er-SOLV16</td>
<td>er-SOLV16</td>
<td>PET, TCO</td>
<td>Solvent-based nanoparticle inkjet inks for printed electronics and related applications</td>
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<td>EMD5603</td>
<td>Padprinting</td>
<td>(5-30)</td>
<td>150-300°C 30 min</td>
<td>50-100 μm</td>
<td>50-100 μm</td>
<td>NA</td>
<td>er-SOLV16</td>
<td>er-SOLV16</td>
<td>PET, TCO</td>
<td>Solvent-based nanoparticle inkjet inks for printed electronics and related applications</td>
<td>6</td>
</tr>
</tbody>
</table>

PTF Selector as of JAN2014
Structure of inks for different applications
Thermal sintering - e.g. Nano-Ag EMD inks

Thermal NIR sintering

150 C for 1 min
Formulating for diff. Applications e.g. Imagecure

- **Imagecure**: Curtain coat inks can be applied by Spray or Screen. However downside is coverage is poor.
  - Screen inks can be sprayed, but not curtain coated.
  - Likewise spray inks can be screen printed, but not curtain coated.

- The final end performance and feature capabilities of all inks irrespective of the application is dependent on the way in which the inks are formulated. A few examples are as follows:
  - Achieve high hardness the choice of fillers is key.
  - Achieve high resolution 50 microns and below the photoinitator package and ratio are critical combined with the developing properties of the ink.
  - Chemically cleaned surfaces will require a product with good flexibility and adhesion.

- However to maximise the final end performance the manufacturing process does need to be in control so as to achieve the best result.
New Product Test Criteria  e.g. Imagecure

All soldermask products are tested to meet IPC SM840-E as a minimum requirement. This covers –

- Pencil Hardness
- Adhesion
- Chemical Requirements
- Resistance to Fabrication Solvents, Cleaning Agents and Fluxes
- Hydrolytic Stability
- Soldering Requirements
- Solderability
- Resistance to Tin-Lead & Lead Free Solder
- Electrical Requirements
- Dielectric Strength
- Insulation Resistance
- Environmental Requirements
- Moisture and Insulation Resistance
- Electrochemical Migration
- Thermal Shock

Flammability is tested to meet UL94V-0
<table>
<thead>
<tr>
<th>Description</th>
<th>Tests undertaken.</th>
<th>Specification</th>
<th>Test Method</th>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td>Visual Requirements</td>
<td>1, 2</td>
<td>IPC-SM-840C 3.4.8</td>
<td></td>
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<tr>
<td>Track Coverage</td>
<td>3</td>
<td>QSE 4.10 FKAT 0512_00</td>
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<td>Pass</td>
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<tr>
<td>Uniform Coverage of LPISM</td>
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<td>IPC-A-600</td>
<td>2.9.7</td>
<td>Pass</td>
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<td>Soda Strawing</td>
<td>5</td>
<td>IPC-A-600</td>
<td>2.9.9 Class 1,2</td>
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<td>Delamination of LPISM</td>
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<td>IPC-6012 3.8.1</td>
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<tr>
<td>Small Hole Development</td>
<td>7</td>
<td>Internal</td>
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<td>Pass</td>
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<tr>
<td>Adhesion of LPISM</td>
<td>8</td>
<td>IPC-SM-840C 3.5.2.1</td>
<td>TM650 2.4.28.1</td>
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<td>Notation Ink Adhesion</td>
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<td>IPC-SM-840C 3.5.2.4</td>
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<td>Conformal Coating Adhesion</td>
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<tr>
<td>Solder Dams</td>
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<td>50 µ dams</td>
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<td>Solder Resistance</td>
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<tr>
<td>Solderability</td>
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<td>Undercut</td>
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</tr>
<tr>
<td>Pencil Hardness</td>
<td>22</td>
<td>IPC-SM-840C / SN657539.9906</td>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td>Machinability</td>
<td>23</td>
<td>IPC-SM-840C 3.5.3</td>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td>Flammability</td>
<td>30</td>
<td>IPC-SM-840C 3.6.3</td>
<td>UL-94</td>
<td>Pass (V0)</td>
</tr>
</tbody>
</table>
# Imagecure Summary of Test Results

<table>
<thead>
<tr>
<th>Description</th>
<th>Tests undertaken.</th>
<th>Specification</th>
<th>Test Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric Strength</td>
<td>12</td>
<td>IPC-SM-840C 3.8.1</td>
<td>TM650 2.5.6.1</td>
<td>Pass</td>
</tr>
<tr>
<td>CTI Value</td>
<td>13</td>
<td>1341 PA16_01</td>
<td></td>
<td>Pass (&gt;400V)</td>
</tr>
<tr>
<td>Hydrolytic Stability</td>
<td>24</td>
<td>IPC-SM-840C 3.6.2</td>
<td>TM650 2.6.11</td>
<td>Pass</td>
</tr>
<tr>
<td>E-Corrosion</td>
<td>25</td>
<td>IPC-SM-840C</td>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bosch BV Y273 R80 029</td>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Siemens SN657539 4960</td>
<td></td>
<td>Pass</td>
</tr>
<tr>
<td>Thermal Cycling</td>
<td>26</td>
<td>IPC-SM-840C 3.9.3</td>
<td>TM650 2.6.7.1</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bosch BV Y273 R80 029</td>
<td>5.1.1 Class TC1</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Siemens SN657539 4960</td>
<td>8.3 Class C</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>Bosch BV Y273 R80 029</td>
<td>Class TC5 &amp; Class TC6</td>
</tr>
<tr>
<td>Hot Temp. Storage</td>
<td>27</td>
<td>Bosch BV Y273 R80 029</td>
<td>5.2 Class TC1</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Siemens SN657539 4960</td>
<td>8.2 Class C</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>Siemens SN657539 4960</td>
<td>8.2 Class D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>Bosch BV Y273 R80 029</td>
<td>5.2 Class TC5 &amp; TC6</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>-</td>
<td>1MHz, 10MHz, 100MHz, 1GHz</td>
<td>3.95, 3.79, 3.63, 3.59</td>
<td></td>
</tr>
<tr>
<td>Dissipation Factor</td>
<td>-</td>
<td>1MHz, 10MHz, 100MHz, 1GHz</td>
<td>0.019, 0.023, 0.023, 0.021</td>
<td></td>
</tr>
</tbody>
</table>
## Isolation Layer Portfolio [extract]

<table>
<thead>
<tr>
<th></th>
<th>Photoimageable System</th>
<th>UV Curing systems</th>
<th>Thermal Cure Polyimide</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product ID</strong></td>
<td>DRP5000</td>
<td>EMD6415</td>
<td>UV600</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Photoimageable isolation layer</td>
<td>UV isolation layer</td>
<td>Thermal polyimide isolation layer</td>
</tr>
<tr>
<td><strong>Application method</strong></td>
<td>Roll coat, spray</td>
<td>Ink Jet</td>
<td>Screen</td>
</tr>
<tr>
<td><strong>Cure</strong></td>
<td>Photoimageable</td>
<td>UV</td>
<td>Thermal</td>
</tr>
<tr>
<td><strong>Cure Schedule</strong></td>
<td>80°C, 1900 mJ/cm²</td>
<td>100-300 mJ/cm² 750-1000 mJ/cm²</td>
<td>250°C/30-60 min.</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>NA</td>
<td>very high res.</td>
<td>low resolution</td>
</tr>
<tr>
<td><strong>Screen mesh</strong></td>
<td>NA</td>
<td>195-355</td>
<td>196-420 µm</td>
</tr>
<tr>
<td><strong>Printed thickness, µm</strong></td>
<td>4-6 µm</td>
<td>12 µm, typical</td>
<td>10-20 µm</td>
</tr>
<tr>
<td><strong>Breakdown voltage, kV/mm</strong></td>
<td></td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td><strong>Thinner</strong></td>
<td>ER-SOLV03</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cleaning solvent</strong></td>
<td>ER-SOLV03 or acetone</td>
<td>EMD0600</td>
<td>ER-SOLV03 or acetone</td>
</tr>
<tr>
<td><strong>Substrates</strong></td>
<td>Glass, active layer CdTe</td>
<td>PET, Al, Cu, silicon nitride</td>
<td>SiO, Al, Cu</td>
</tr>
</tbody>
</table>
### Thermal Cure Etch Resists

<table>
<thead>
<tr>
<th>Product ID</th>
<th>ESTA1100</th>
<th>ESTA1150</th>
<th>ESTA1170</th>
<th>EETA1200</th>
<th>ERTA1300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Etch Resist</td>
<td>Etch Resist</td>
<td>Etch Resist</td>
<td>Etch Resist</td>
<td>Etch Resist</td>
</tr>
<tr>
<td>Application method</td>
<td>Screen</td>
<td>Edge Coat</td>
<td>Roll Coat</td>
<td>Ink jet</td>
<td>Hot Melt - Ambient</td>
</tr>
<tr>
<td>Cure</td>
<td>Thermal</td>
<td>Thermal</td>
<td>NA</td>
<td>Hot Melt - Ambient</td>
<td>NA</td>
</tr>
<tr>
<td>Cure Schedule</td>
<td>3-10 min @ 110°C to 140°C</td>
<td>3-10 min @ 110°C to 140°C</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Resolution</td>
<td>100 µm</td>
<td>125 µm</td>
<td>50 µm</td>
<td>100 µm</td>
<td>NA</td>
</tr>
<tr>
<td>Screen mesh</td>
<td>305/in to 420/in monofilament polyester or SS</td>
<td>Roll coat</td>
<td>Roll coat</td>
<td>Roll coat</td>
<td>NA</td>
</tr>
<tr>
<td>Printed thickness</td>
<td>8-12 µm</td>
<td>Variable</td>
<td>5-7 µm</td>
<td>12-24 µm</td>
<td>NA</td>
</tr>
<tr>
<td>Thinner</td>
<td>ER-SOLV01</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Substrates</td>
<td>Silicon, Silicon nitride, Copper, ITO</td>
<td>Si, SiNx, textured Si</td>
<td>Si, SiNx, textured Si</td>
<td>Si, SiNx, textured Si</td>
<td>Si, SiNx, textured Si</td>
</tr>
<tr>
<td>Etch Chemistries</td>
<td>HF, HF-HNO₃, other</td>
<td>HF, other</td>
<td>HF, other</td>
<td>HF, other</td>
<td>HF, other</td>
</tr>
<tr>
<td>HF Resistance</td>
<td>Fair</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Strip Conditions</td>
<td>2% KOH @40°C</td>
<td>&lt;2% KOH @30-50°C or naphtha</td>
<td>&lt;2% KOH @30-50°C or naphtha</td>
<td>&lt;2% KOH @30-50°C or naphtha</td>
<td>&lt;2% KOH @30-50°C or naphtha</td>
</tr>
<tr>
<td>Application</td>
<td>SE, RC, EWT, MWT, PERC, PERL</td>
<td>SE, RC, EWT, MWT, PERC, PERL</td>
<td>SE, RC, EWT, MWT, PERC, PERL</td>
<td>SE, RC, EWT, MWT, PERC, PERL</td>
<td>SE, RC, EWT, MWT, PERC, PERL</td>
</tr>
</tbody>
</table>
SunTronic® Inks Nomenclature

- **AST** Argentum Screen Thermal
- **APT** Argentum Pad Thermal
- **AFT** Argentum Flexo [WB Waterbased like Aqualine]
- **DSU** Dielectric Screen UV
- **GST** Grafite/Carbon Screen Therma
- **GFT** Grafite/Carbon Flexo Thermal
- **GGT** Grafite/Carbon Gravure
- **EMD** EM Digital
- **CXT** Lab Code eXperimental Thermal
- **LSF** Alu Cellmet c-Si
Testing capabilities - bold font is for mandatory tests for any PTF Ink

- **Viscosity**
- **Electrical properties** - sheet resistivity, volume resistivity, withstand voltage and dielectric breakdown for dielectric inks
- **Ink film thickness**
- **Ink film roughness**
- **Total solids (silver + resin) at 120 deg C**
- **Density**
- **Printability** (standard is 1mm meander line resistor – 600 squares), for fine line applications we currently have capabilities in STC to print down to 75 microns nominal lines/gaps with SS screens
- **Cross-hatch adhesion to PET** (we use Melinex ST505 as a standard, other substrate are tested upon request).
- **Shelf life/storage conditions**
- **Drying conditions**
- **Crease resistance**
- **Screen stability**
- **Coverage**
- **% Resistance change under flexing**
- **Nail scratch resistance**
- **Pencil hardness**
- **Environmental stability**
- **Compatibility with carbons and dielectrics / Cross over compatibility**
**SunTronic® Inks for Printed Electronics Applications**

### General Purpose PTF Silvers
(15-20 mOhms/sq/mil)

- **AST6000** – excellent adhesion to various substrates
- **AST6200** – high flexibility
- **AST6201** – flexible and cost effective
- **AST6400** – highly elastic, excellent crease resistance and thermo formable

### Applications:
- Membrane touch switch,
- Capacitive and resistive switches
- Automotive and consumer electronics
SunTronic® Inks for Printed Electronics Applications Cont.

High Conductivity Silver Inks
(10-15 mOhms/sq/mil)

- AST6010 – screen ink
- AST6140 – screen ink
- CXT-0693 – rotary screen ink
- APT6003 – pad printable
- AFT6700 – flexo printable

Applications:
- Highly conductive circuitry
- Printed antennae – RFID, NFC
- Inductive coils
- Antennae for mobile devices – printed on 3D surface
Silver Inks for bus bars for resistive and capacitive touch panels (TP)

**Focus areas:**
- Fine-line printable
- Laser ablatable

**Developmental Screen Inks**
- CXT-0668 – excellent fine-line printability, great solvent resistance, fast drying, excellent adhesion to various surfaces
- CXT-0667 – excellent fine-line printability, long screen life, excellent adhesion to various surfaces
- CXT-0644 – excellent fine line printability <50 microns
- Laser ablatable ink under development
SunTronic® Inks for Printed Electronics Applications Cont.

Carbon/Graphite Conductive Inks

**Screen Inks**
- **GST4200** – general purpose, compatible with AST6000, great adhesion to various substrates
- **GST4300** – general purpose, compatible with AST6200, flexible
- **GST4400** – excellent laser ablation capability
- **GST4500** – very flexible, crinkle/crumple resistant, fast drying

**Flexo and Gravure Inks**
- **GFT4600** – water based
- **GFT4602** – solvent based
- **GGT4605** – solvent based

**Applications:**
- Membrane touch switch
- Capacitive and resistive switches
- Automotive and consumer electronics
- Antennae
- Smart labels
- Interactive cards
- Electrostatic dissipation
## UV Curable Isolation Inks – clear or blue version

<table>
<thead>
<tr>
<th>Inks</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSU4601C</td>
<td>• Excellent dielectric properties</td>
</tr>
<tr>
<td>DSU4601B</td>
<td>• Adhesion to various substrates</td>
</tr>
<tr>
<td></td>
<td>• Excellent environmental stability</td>
</tr>
<tr>
<td>DSU4603C</td>
<td>• Best leveling and smooth surface</td>
</tr>
<tr>
<td>DSU4603B</td>
<td>• Maximum flexibility</td>
</tr>
<tr>
<td></td>
<td>• Excellent environmental stability</td>
</tr>
<tr>
<td>DSU4604C</td>
<td>• Excellent printability, high definition</td>
</tr>
<tr>
<td>DSU4604B</td>
<td>• Maximum flexibility</td>
</tr>
<tr>
<td></td>
<td>• Excellent environmental stability</td>
</tr>
</tbody>
</table>
“Building our future together”

Any questions?

¿Alguna Pregunta?

Sun Chemical working together on Printed Electronics Applications

Frank Eirmbter  
Business Development Manager  
Electronic Materials  
Sun Chemical

working for you

Frank EIRMBTER  frank.eirmbter@sunchemical.com
Thank you!