Electronic Materials Enterprise
New Developments in Substrates
The New Electronic Materials Enterprise

Introducing a new ~$5B technology leader with a unique depth and breadth of knowledge, applications and technical expertise, and product portfolio to address customers’ needs.

Serving the semiconductor, advanced chip packaging, circuit board, electronic and industrial finishing, photovoltaic, display, and digital and flexographic printing industries. The new DuPont Electronics!

Macro Trends in The World Today Driving Materials

- Connectivity
- Miniaturization
- Industrial Automation
- Artificial Intelligence
- Urbanization
- Increased Content
- Health Informatics and Sensing
- Renewable Energy
# Electronics & Imaging Business Overview

| Semiconductor Technologies | ✔️ CMP pads and slurries  
|                          | ✔️ Photolithography materials  
|                          | ✔️ Advanced packaging materials  
|                          | ✔️ Silicon-based CVD & ALD precursors  
|                          | ✔️ Silicones for semiconductor packaging  
| Circuit & Industrial Technologies | ✔️ Metallization materials  
|                                    | ✔️ Imaging materials  
|                                    | ✔️ Surface finishes  
| Photovoltaic and Advanced Materials | ✔️ PV encapsulants  
|                                           | ✔️ Sealants for panel assembly  
|                                           | ✔️ Trichlorosilane for polysilicon wafers  
| Advanced Printing | ✔️ PV metallization pastes  
|                          | ✔️ Thick film pastes  
|                          | ✔️ Polyvinyl fluoromaterials  
| Display Technologies | ✔️ OLED materials  
|                          | ✔️ Cadmium-free quantum dot materials  
|                          | ✔️ Display process chemicals  
|                          | ✔️ Silicones for LED packaging  
|                          | ✔️ Silicones for display assembly  
|                          | ✔️ Removers and cleaners  
|                          | ✔️ Polyimide films and laminates  
|                          | ✔️ Dry film photoresists  
|                          | ✔️ Flexographic plates and materials  
|                          | ✔️ Digital inks  
|                          | ✔️ OLED materials  
|                          | ✔️ Display enhancements  

Electronics & Imaging
Circuit & Industrial Technologies

Broader offerings and application expertise for today’s circuit boards

Specialized films and finishing technologies that enable advances in industrial applications

Metallization Materials  Polyimide Films
Imaging Materials  Advanced Laminates
Surface Treatment  Dry Film Photoresist

Major Market

- Smartphones & Consumer Electronics
- Autonomous & Electric Vehicles
- Network & Telecom
- High Speed Rail & Traction Motors
- Military & Aero
- Electronic Components & Industrial Finishing

Substrate  Metallization  Resist  Imaging/Dev  Etch  Resist Removal  Packaging
Requirements for Next Generation Smart Devices are Increasing

- Increased functionalities
- High Performance
- Low Power Consumption
- Miniaturization
- Lower cost
- Environmentally friendly
- Flexible materials

Emerging Applications

Evolution of Smartphones

Increased device Integration
Semiconductor, Packaging & Substrate Evolution

Integration: 2D 3D

Time

Substrates:
PCB Substrates: Subtractive, mSAP
IC Substrates: mSAP, pSAP, SAP, ETS, Interposers

Interconnect:
Through-hole

Complexity / Technology Advancements

Lead-frames, Wirebonding, Bumping, Pillars, Studs, RDLs, TSVs, THV, TMV, Via Fill, optical, ...
Stacking
SiP
3DIC-TSV
Embedded Die/Fan-out
SIP Module

CMOS
50 Years of Innovation Driven by Moore’s Law…

…have also driven development of various interconnect technologies

Chemistry is in every step of chip manufacture

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Advanced Packaging Growing Faster than Semi

Source: Gartner, Yole

=> Advanced Packaging is growing at a much faster rate than Semi
Films & Laminates Applications / Circuits

**Riston® Dry Films**
- MSAP DI5
- Dual-Band DI9
- DI7 355nm
- DI8 405nm
- Conv HDI
- WetLam® Advance

**Pyralux® Laminates**
- 2 µm, 9 µm, 12 µm Cu ultra-thin FCCL
- 9 µm, 12 µm PI Coverlay
- M&IR Adhesive

**Kapton® Films**
- Thin TPI
- 40EN, 30EN, 20EN
- Plateable PI Films
- COF Sputter Films
- Substrates for MSAP

**Thin Form Factors & Fine Patterning**
- Thin TPI
- 40EN, 30EN, 20EN
- Plateable PI Films
- COF Sputter Films
- Substrates for MSAP

**High Speed High Frequency**
- TK Laminates (fluoro-PI)
- AP Sheet Clads
- TA Roll Clads
- HK04J (embedded passives)
- Low Loss Adhesive

**Innovation**
- Ultra Matte Black, UMB
- White Film and Clear Film
- Flex Display Film
- CTE-Matched Film
- Metallized Films for MSAP

Electronics & Imaging
Examples of Packages & Technologies found in Smartphones

- APU / DRAM
- Fan-out or FC based PoP
- CMOS Image Sensor
- WLP, FC, 3DIC Integration
- Power Amplifier/RF
- SiP based Packages, Pillars, Solder and 3DIC Integration

Source: Yole Developpement

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mSAP: Emerging Standard for Fine-line Interconnect

Note: includes only key process steps
Space & Trace Size for iPhones over 10 Years

Subtractive Etch (L/S)

Modified Semi Additive Processing (L/S) - mSAP
Traditional Approach is Limited - THINNERIZATION
Transitioning Consumer Electronic “Mother Boards” from “Rigid” to “Flex”

Designers are shrinking in the X-Y plane using MSAP processing w/o thinking about Z-axis miniaturization requirements !!!

Current rigid dielectrics (glass/epoxy) can not be made thin enough for 10-Layer stack at 200-300um,

Transitioning from Rigid to Flexible Dielectric Layers Can solve many design problems

Reason for using MSAP for Smartphone Motherboard

✓ Miniaturization and densification of Mother Board to enlarge battery space.
✓ Narrower BGA ball pitch to improve the function of IC package
✓ Improvement of signal characteristics in high speed signal
New View – Integrated Multi-layer Boards using All-Flex

All Flex Material Mother boards, or Combinations of Rigid Core / Flex Build up
The Pyralux® portfolio includes a diverse collection of core dielectric materials and customized dimensional constructions that enable the designer and manufacturer of complex circuits to deliver high performance solutions.

- Copper clad laminates, bondplys, coverlays, and adhesive systems
- Fabrication of thin, solderable, high density electrical interconnects for single and double-sided, multilayer flex and rigid flex applications

### Features & Benefits

- Wide range of thickness and constructions
- Excellent thermal, chemical and mechanical properties
- Highest certified service temperature
- Lower Dk, Df properties
- Engineered CTE properties
- System offerings (clads, cladplys, bondplys, adhesives) designed to work together for greater design latitude

### Applications

- Flex for Smart Electronics, e.g. phones, tablets, PCs
- Flex for Fine-Line Display, e.g. COF, Rigid-Flex
- Flex for Servers, Routers, Telecom
- Reliability Flex in Automotive and Medical
- Military and Aerospace PCBs
- Embedded Passive Design PCBs
- Flex for Antenna and Data Cables
What does THINNERIZATION mean?

DuPont Pyralux vs. Rigid  5x Mag (12 Layer side by side comparison)
12 Layers

All Cu layers etched to 3 um, then 12um Electroplated Cu on each layer
Total Cu thickness is ~15 um
Total Dielectric Layer (4 PI + 18 Epoxy)

Total thickness for 12 layers (with no adhesive squeeze out), 425 um

Incumbent rigid board is 2x thick
Very Popular Mother Board – Comparison Chart (drawn to scale)

Reduces total board thickness from ~580 um to 225-275 um

Achieves 5-20 um L/S and high micro via pitch density (e.g. 1000-2000 I/O)

Flexible – curved shapes, like a watch
We need an ultra-thin microvia test vehicle constructed to characterize reliability of polyimide versus prepreg.

The test vehicle, as constructed with available thin prepreg material is about 700-750 μm thick for 12 layers.

The equivalent polyimide based solution will be about half thickness, ~350 μm.

75 micron via drill, 100 micron pad, all-layer stacked via construction.
iWatch Mother Boards –

Flexible Multilayer Board Design Goals

1) Reduce thickness by >50%

2) Increase via density to 1000/cm²

3) Achieve / beat new L/S requirements

4) Improve electrical performance
   1) Lower dK to below 3.5
   2) Lower insertion loss
   3) Lower CTE – better dim stabs

5) Transition from Rigid to Flex
   1) Bendable/Curved boards/devices
   2) Shorter signal paths, shorter vias
   3) Finer L/S (15, 10, 5)
Thank You