Solving Integration Challenges for Flexible Hybrid Electronics

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Approved for Public Release
Flexible Hybrid System
“Combination of flexible printed materials and flexible silicon-based ICs to create a new class of flexible electronics.”

Printed Electronics
- Sensors
- Interconnects
- Substrates
- Displays
- Low Cost, Large Format
- Roll-To-Roll, Screen, Inkjet Print, …

Flexible FleX-ICs
- High Performance, High Density
- Sensor Signal Processing
- Data Processing
- Data Storage
- Communications
- Low Cost, High Performance
- Compatible with Printed Electronics
- Foundry CMOS + FleX Processing

Molex flexible substrate
Killer Apps – What are they?

Products are starting to emerge

- Asset Monitoring Systems for structural, quality, and performance

- Wearable monitoring for Medical and Performance

- Consumer product safety, new features.
**Basic FHE Manufacturing Process**

**Flexible Substrate Fabrication**
- Flexible Circuit Boards
- Screen Print
- Roll-2-Roll

**Semiconductor IC**
- Pakaged IC
- Die IC
  - Thin Die: < 50um
  - Ultra-thin/SoP Die: < 12um

**Flexible Hybridization**
- IC attach
- IC interconnect
- IC Overcoat
- Testing
- Lamination
- Surface mount
- Printing

**Integration**

**Sensors/display**
- Printed material
- Surface mount
- Unique Material

**FHE**
Flexible ICs required to achieve a fully flexible system

• Traditional packaged parts and bare die can be surface mounted to flexible substrates
  ‣ Create rigid “islands” in flex substrates and/or
  ‣ Rigid parts delaminate with even gentle curvature

Test Setup:
- Vdd = 2.5V
- Vss = 0V
- Ibias = 10uA
- In-pos = 1kHz square wave (YELLOW trace on oscilloscope)
- In-neg = connected to Out, voltage follower configuration (BLUE trace on scope)
- Out= connected to In-neg, voltage follower configuration (BLUE trace on scope)

Flex Op-Amp functions at 5mm radius of curvature!
Active areas of integration current development

Ultra-Thin Die and SoP Dicing
- <50um Thickness
- New edge issues
- Release film is critical

Die interconnect for volume manufacturing
- Physical flexibility after cure
- Electrical conductivity versus bulk silver
- Printability: pitch capability, z-height requirements, thermal budget
- Manufacturability: throughput, total COO
- Z-Axis methods have been demonstrated and are in development for volume manufacturing

Pick & Place and Die attach
- Currently Manual
- Automation in R&D
- Flexibility is a new pick and attach issue
- New attach material requirements
Thick Die Overcoat

- Original die overcoat is ~600um thick at highest point, the “dome” of the material
- Prevents physical die/interconnect damage
- Thick material loses flexibility at ~40mm radius curvature
- Inflexible material can delaminate from FCB
Improved die overcoat is ~120um thick at highest point, the topography formed by the printed interconnect over the die edge.

- Prevents physical die/interconnect damage.
- Thinner material remains very flexible down to 5mm radius curvature testing limit.
- Flexible material has no delamination.
Reliability Standards and Tests are an active area of FHE Development.

- FHE provided unique challenges for testing and reliability
- Standards for FHE have yet to emerge
- Testing methods are being developed
- Test associated with flexibility pioneer new characteristics.
- Radius of Curvature is one important new reliability characteristic
- Rcurve is a test method currently being developed and utilized for early stage FHE products.
- Unique qualification test requirements have also been adopted to support the release of the FleXform-ADC™ Dev Kit.

Rcurve - radius of curvature testing
FleXform-ADC Kits provide:
- SOTA FHE System
- Supports printed sensor development
- User printable FHE with on-board FleX-ADC™
- Integration Board and Software
- Enables printed device demonstrations
- Fully supported by ASI flexible technology integration team for design and manufacturing

FleXform-ADC Kit contents:
- Quick Start Guide
- FleXform-ADC printed circuit board (PCB)
- Two button cell batteries
- One 8.5” X 5.5” flexible circuit board sheet with two instances of the FleXform-ADC flexible circuit board (FCB)
- Additional documentation, videos and software development tools are available for download
Brewer Science/American Semiconductor collaboration

- FleXform-ADC™ Dev Kit (FleX ADC IC)
- Temperature and humidity sensors (printed SWCNT)

Temperature Testing

Humidity Testing

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<tr>
<th>Humidity</th>
<th>Code</th>
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<tr>
<td>35%</td>
<td>74</td>
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<tr>
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FHE and Evaluation Board
New Boise, Idaho Facility – Headquarters and Manufacturing

- Small Business
- Privately Held
- Founded Nov. 2001

Member:

- Flexible Hybrid Assembly
- IC Design
- Antenna Design
- FleX-ICs

- Thin Wafer Processing
- FHE System Integration
- Failure Analysis
- FleXform™ Dev Kits

9,000 s.f. FHE Manufacturing Facility
Thank you for attending

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