FHE Integration & Manufacturing for Killer Apps

Nov. 18, 2015

Doug Hackler
• Small Business
• Privately Held
• Founded Nov. 2001

Member:

New Boise, Idaho Facility – Headquarters and manufacturing

9,000 s.f. FHE Manufacturing Facility

• Flexible Hybrid Assembly
• IC Design
• Antenna Design
• FleX-IC’s (SoP)

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

Flexible Hybrid Lab

Class 100 Cleanroom
Products are starting to emerge

- Asset Monitoring Systems for structural, quality and performance
- Wearable monitoring for Medical and Performance
- Consumer product safety, new features.
**Printed Electronics**
- Low Cost, R2R, Large Format

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

**Flexible FleX-ICs**
- High Performance, High Density

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

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**Basic FHE Manufacturing Process**

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

**Flexible Substrate Fabrication**
- Screen Print
- Roll-2-Roll
- Sheets or Roll

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

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

**Integration**

**FHE**
IC’s are required for logic, memory and communications

- Packaged parts can be surface mounted
- Bare die (300um typical) and Thin IC’s (<50um ) can be used
- Ultra-thin die (<12um) and SoP die are fully flexible
- SOP ADC, MCU and OPAMO are commercially available

**FleX 8-bit ADC**

- 8-bit ADC
- 2.5V
- Flexible and conformal

**Product Overview**
- 8-bit ADC
- Low Power

**Product Features**
- 8-bit Successive Approximation ADC
- 8 input, 100k s/s
- Single and continuous
- 2-wire I²C communication

**FleX-MCU™**

- 8-bit Microcontroller

**Product Overview**
- 8-bit ADC
- 2.5V
- Flexible and conformal

**Product Features**
- RISC microcontroller
- ROM and SRAM
- UART, I2C and SPI comm.
- Multiple programmable timers
- Multiple GPIO ports for sensor data collection

**FleX OPAMP**

- Flex Op-Amp functions at 5mm radius of curvature.

**Test Setup:**
- Vdd = 2.5V
- Vss = 0V
- Ibias = 10uA
- In-pos = 1kHz square wave
- In-neg = connected to Out, voltage follower configuration
- Out = connected to In-neg, voltage follower configuration
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

Active areas of integration current development
Overcoat

- Reliability requirement
  - Scratch protection
  - Environmental protection
- Mechanical Requirements
  - Conformal
  - Thin
  - Flexible

FleXform-ADC Overcoat
- “Beta” Units
  - 600um thickness
  - Rcurve Test limit 40mm
- Gen 1 Units
  - 120um thickness
  - Rcurve Test limit <5mm
- 80% thinner, ~90% more flexible
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.
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

This work sponsored in part by Air Force Research Laboratory
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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<th>Humidity</th>
<th>Code</th>
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<td>35%</td>
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Thank you for attending

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