Solving Integration Challenges for Flexible Hybrid Electronics

High performance flexible electronics
Wearable Sensor System Configurations

Wearable Hybrid System

Sensor -> Signal Processing -> Data Processing -> Comm -> User Display
Wearable Hybrid Commercial Electronics Manufacturing

- Integrators are needed (suppliers)
- Designers need technology to work with

**IC Design** > **Silicon IC Fabrication** > **SoP**
- Hybrid
- Need Reliability data & Standards

- Mature Capability
- Capability & Suppliers
- One Supplier

**Printed Circuits & Sensor Design** > **Printed Electronics**
- Need Reliability data & Standards
- Integrators are needed (suppliers)

- Lots of tools & Inks
- Few Suppliers

**2015 Product Development**
- Requires suppliers

- **FHE Assembly (2014)**
- **2015 Products in Market**

- Requires Mfg Capacity. Not yet available.
IC’s for wearable hybrid systems

Silicon-on-Polymer (SoP) converts single crystalline semiconductors into flexible semiconductors.

FleX™ commercial SoP CMOS process.
"Rainbow™" FHS Assembly Test & Reliability Tools

**Purpose:** Assembly Technology Development

**Rainbow Strip Test Coupon:**
- Flexible circuit board compatible with: MEC die, FleX SoP Die, Std Die
- Rcurve Test Platform
- Mechanical or Environmental testing

**Rainbow Demonstrator:**
- Development tool
- Electrical verification of assembly methods
- Functional test board

Tests and Standards in Development
Signal processing - The foundation for sensor integration

Wearable Hybrid System

Sensor \[\xrightarrow{\text{Signal Processing}}\] Data Processing \[\xrightarrow{\text{Comm}}\] User Display

Needs to be done near to sensor. Solution for low power and SNR.

Signal Processing = Amplification (if required) + Analog to Digital Conversion (ADC)
FleX-ADC™ Flexible Analog-to-Digital Converter

**Features**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>2.5V</td>
</tr>
<tr>
<td>Analog Input Channels</td>
<td>8</td>
</tr>
<tr>
<td>Resolution</td>
<td>8 bits</td>
</tr>
<tr>
<td>Operating Frequency</td>
<td>1MHz</td>
</tr>
<tr>
<td>Internal Oscillator</td>
<td>Yes; 1MHz</td>
</tr>
<tr>
<td>Conversion rate</td>
<td>100ksps</td>
</tr>
<tr>
<td>Communication</td>
<td>2-wire I²C™</td>
</tr>
<tr>
<td>Conversion Modes</td>
<td>Single, Continuous, Scan</td>
</tr>
<tr>
<td>Channel Select</td>
<td>User Configurable</td>
</tr>
</tbody>
</table>

**Process Details**

<table>
<thead>
<tr>
<th>Category</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Technology</td>
<td>TowerJazz 180nm PD-SOI</td>
</tr>
<tr>
<td>Interconnect</td>
<td>4-level Aluminum</td>
</tr>
<tr>
<td>Flexibility</td>
<td>FleX Silicon-on-Polymer</td>
</tr>
</tbody>
</table>

**Physical Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Die Size</td>
<td>2.4mm X 2.4mm</td>
</tr>
<tr>
<td>Pin Count</td>
<td>24</td>
</tr>
<tr>
<td>Pad Opening</td>
<td>160um X 160um</td>
</tr>
<tr>
<td>Pad Pitch</td>
<td>300um</td>
</tr>
<tr>
<td>Thickness</td>
<td>24-60um; based on polymer</td>
</tr>
<tr>
<td>Flexible</td>
<td>Yes</td>
</tr>
<tr>
<td>Conformal</td>
<td>Yes</td>
</tr>
<tr>
<td>Mass</td>
<td>0.23mg</td>
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</tbody>
</table>

AS_ADC1002 8-Bit ADC Conventional vs Flexible

Voltage vs ADC Reading

- AS_ADC1002.fxd (Flex die)
- AS_ADC1002.pkg (Conventional Packaged Die)
Hybrid Manufacturing Infrastructure

- Hybrid Assembly
- IC Design
- SoP
- Integration
- Test
- FA
- R&D

New 9,000 s.f. Manufacturing Facility

Groundbreaking Jan 26, 2015

Goal: Establish an integrator that can provide capacity

Commercial hybrid manufacturing capacity starting summer 2015
Boise, Idaho
Enabler for Wearable Sensor Product: FleXform-ADC™ Development Kit

Platform for new product developers and printed researchers

- Integrate flexible sensors with electronics
- Enable concept demonstrations and low volume initial production

Users can fabricate/mount user’s technology on a hybrid electronic substrate with on board flexible ADC capability for development and demonstrations of the user’s ideas.

Support for this work has been provided by AFRL FA8650-14-C-5010
FleXform-ADC: User printable FHS

• User Printable FHS
• 6 Sensor Areas
  » Labeled According to ADC Channel
  » Each supplied with 2.5V and GND
  » A1 => OPAMP0
  » A2 => OPAMP1
• Practice FCB
• Integrates novel sensors with flexible electronics.
• Cut to form after sensor printing
FleXform-ADC™ Development Kit

FleXform Kits provide:

- “Out-of-the-box” proof of FHE feasibility
- 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.

Kit Availability:

- Limited initial release 2/23/15
- Now accepting pre-orders for March deliveries.