Flexible Single Crystalline ICs from Commercial Foundry Processes for Flexible Hybrid Systems

Prepared for: LOPE-C

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Corporate Headquarters – Boise, Idaho, USA
- Engineering – Design, Process, Modeling
- FleX™ Silicon-on-Polymer™ Mfg and Assembly
- Test & Characterization Cleanroom
- Sales, Marketing, Administration

Process Engineering Center – Santa Clara, CA

Manufacturing – pilot SoP operations

Small Business
Privately Held
Founded November, 2001

Product Lines
- FleX™ – Silicon-on-Polymer™ (Flexible ICs)
- Design Services – Turnkey Design Solutions
FleX Silicon-on-Polymer (SoP) provides the flexible solution we need TODAY.

- SoP – Single crystalline high mobility
- **FLEXIBLE** High performance CMOS
- High density, low power logic
- High density memory
- High speed communications
- Currently Available chipset:
  - MCU
  - ADC
  - RFIC
- Manufacturing Infrastructure
Flexible Systems (2013)

The Parts Exist

One Application Example

Fly-by-feel

Conformal Load Bearing Antenna

Pliable Smart Sensor System

FleX IC

2013 “Flexible Hybrid Systems” (FHS)

(Flexible Hybrid Systems & CLAS – 2013FLEX 8.7)

CS13 CMOS FleX™ qualified

Burghartz “Ultra-Thin Chips and Related Applications, A New Paradigm in Silicon Technology,”
Flexible Hybrid System
“Combination of flexible printed materials and flexible silicon-based ICs to create a new class of flexible electronics.”

Printed Electronics
Low Cost, R2R, Large Format

Flexible Flex ICs
High Performance, High Density

Smart Cards:
- SIM/PIV/CIV
- Identity
- Finance
- Contacted
- Contactless

Consumer:
- Tablets
- Phones
- eReader
- Ultra-thin
- Flexible

Fly-by-Feel:
- Conformal
- Structural
- Antenna
- Sensors
- Ruggedness
- Durability
Our greatest industry challenge: Creating & introducing successful products

- Flexible product development programs are critical
  - Commercial Businesses
  - Research Institutions and Universities
  - Government
- Low cost flexible electronics platform technology must be available
- A total system solution is required
  - Proven technology that meets product requirements
  - Technology that is “mature enough”
  - Technology supported by manufacturing
- Necessary technology is not available today, but we are getting closer...
- Development Kits can provide product designers the necessary platform
- Kit development and availability will be covered in this presentation
Flexible Hybrid Process Integration

IC Design → IC Fabrication → IC FleX SoP Conversion

Current Focus
- FleX-MCU™
- FleX-ADC™
- FleX-RFIC™

Printed Circuits & Sensor Design → Printed Electronics Fabrication

Development to meet FHS Technology Roadmap
- Printed electronics capacity and FleX IC Fabrication are well established
- Current state-of-the-art development is focused on FHS assembly
- Assembly:
  - FHS Design methods and tools
  - FleX Die singulation and handling
  - Die Attach and connect
  - Encapsulation

FHS Assembly (2014)
Feb 2014 Announcement at Flextech

- Tested before and after FleX processing
- Tests passing at up to 12MHz (limited by test environment, not silicon)
- ~2.2M transistors
- Over 275,000 passing digital test vectors

<table>
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<tr>
<th>Block</th>
<th>Full Thickness</th>
<th>FleX Wafer</th>
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<td>CPU - Opcodes</td>
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<td>CPU - ALU</td>
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<td>RAM - 8KB</td>
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<td>Pass</td>
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<td>ROM - 1KB</td>
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<tr>
<td>I/O Ports</td>
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<td>Comm Peripherals</td>
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<tr>
<td>Timers / Counters</td>
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Flexible Hybrid System
“Combination of flexible printed materials and flexible silicon-based ICs to create a new class of flexible electronics.”

FleX IC Product Roadmap
- **FleX-MCU™**: adds NVM
- **FleX-NVM™**: Non-Volatile Memory
- **FleX-LNA™**: standalone Low Noise Amplifier
- **FleX-MCU™**: adds 8-bit ADC and RFID 915MHz transmitter
- **FleX-ADC™**: standalone 8-bit Analog-to-Digital Converter
- **FleX-RFIC™**: standalone 915MHz RF transmitter
- **FleX-ASIC**: custom ICs

Printed Electronics
Low Cost, R2R, Large Format
Purpose: Assembly Technology Development (demonstrate FHS manufacturing)

BOM:
- FleX test die
- FleX-MCU – flexible IC
- Flexible printed circuits
- Rainbow demonstrator

Rainbow Demonstrator:
- Development tool
- Fully flexible demonstration
- Electrical verification of assembly methods
- Verification/demonstration of MCU capability
PRODUCTS are what our industry needs
Products require concept demonstrations
Capability is needed to enable product development

**New Technology Announcement: FleXform**

**FleXform** is a kit platform for product developers

**FleXForm**: Flexible development hardware
- FleX-MCU on a flexible demo board
- Standard connectors for interfacing to PC and prototyping boards
- Flexible, printed display and buttons
- Voltage regulators
- Serial EEPROM

**FleXform**: Software & Documentation
- C-compiler and assembler
- Product specifications
- User’s guide
- Data sheet
- Demonstration software
User Flexible Display Region

User makes connections to from user device to existing printed pads.

Connections to printed pads made by user or ASI.

Software and Documentation
C-compiler & Assembler
EEPROM Programming
User's Guide & Specifications

User prints or applies flexible sensors and/or displays.

User Printable Sensor Region

FleX-MCU
5mm X 5mm
8-bit RISC CPU
8KB SRAM, 2KB ROM
UART, SPI, I2C
18 I/O – 2.5V CMOS

Available Dec. 2014

Prototyping Board
PC interface
EEPROM for User Code
Voltage Regulators

54 mm
85 mm
50 mm
Thank You