Role of Conventional Silicon ICs in Flexible Electronics

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The Flexible problem is a Silicon Opportunity

**Problem: No ICs = No Flexible Electronic Features**
Conventional ICs have the needed features, but are brittle and require assembly methods that are incompatible with printed manufacturing. Thin Film Transistors (TFT) cannot provide the needed performance or density.

**Opportunity**
Flexible electronics offers a whole new world in electronic product designs and markets. If we can apply semiconductor industry design and infrastructure, we can leverage and reuse silicon in new markets.
The Flexible problem is a Silicon Opportunity

The FleX™ technology presented today shows how standard CMOS foundry wafer processing can be applied to flexible systems.
Flexible Electronic Products and Services Provider

Corporate Headquarters – Boise, ID
- 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
- Design Services – Turnkey Design Solutions
Flexible CMOS (2009 - 2012)

![Image: Flexible CMOS](image)

**FleX Silicon-On-Polymer Foundry Roadmap**

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Today (July 2013)

- Orders of magnitude faster, at lower voltage!

![Graph: Time delay per stage (s)](image)

- p-channel circuits
- n-channel circuits
- complementary circuits

PEALD ZnO TFTs
Electron Devices, Feb. 2010

- Organic Thin Film Transistors
- Flex CMOS
- Feb. 2011


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Relevant Markets and Opportunities

Printed Electronics
Low Cost, R2R, Large Format

Flexible Hybrid System (FHS)
“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

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

Consumer:
Tablets
Phones
eReader
Ultra-thin
Flexible

Automotive/Aerospace:
Conformal
Structural Integration
Sensors
Fly-by-Feel
Rugged & Durable
FleX Option for Jazz CS18/13

Jazz CS18-FleX is the industry’s first commercially available flexible CMOS foundry process

Characterization of CS18 in FleX is underway

First wafers show excellent mechanical properties

DC data pre- and post-FleX show no shift in transistor performance

RF FleX testing shows good initial results

Initial characterization data will provide a preliminary CS18-FleX PDK for prototyping

CS18 PMOS Top, NMOS Bottom
Full Thickness data in red; FleX data in blue
**FleX** Option for Jazz CS18/13

- **Jazz CS18/CS13 (180/130nm) SOI CMOS**
  - Partially depleted thin SOI process
  - Floating body & body contacted devices
  - 2fF/um² MIM Capacitor
  - Low and high value salicided poly resistors
  - Four Al metal levels with 3um thick top metal

- Process Design Kits available for both Cadence and Silvaco based EDA flows

- Design libraries and reusable IP are in development

- Regular multi-project wafer (MPW) wafer lots provide low cost options for manufacturing test chips, prototypes and key IP building blocks
FleX-IC Product Roadmap

FleX ICs
High Performance, High Density Physically Flexible Silicon

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

FleX™ IC Product Roadmap

- FleX-MCU™ (8-bit RISC, 1.2V core, 2.5V I/O, UART, I2C, SPI; Sampling early Q4’13)
- FleX-NVM™ (Non-Volatile Memory)
- FleX-LNA™ (standalone Low Noise Amplifier)
- FleX-ASIC (custom ICs)
- FleX-RFIC™ (860-960MHz (UHF) IP-X™ TTO RFID; 64-bit UID, 0.1m–10m range, Sampling late Q4’13)
- FleX-ADC™ (8-bit Analog-to-Digital Converter; 100k samples/s, I2C, 2.5V; Sampling late Q4’13)

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FleX-MCU™ Microcontroller
First Flexible High Performance Logic IC

Product Overview
- Low-power general purpose microcontroller
  - >1.5M transistors
- FleX SoP process with 130nm CMOS

Product Features
- TowerJazz 130nm SOI CMOS with FleX option
- RISC microcontroller
- ROM and SRAM
- UART, I2C and SPI communication
- Multiple programmable timers
- Multiple GPIO ports for sensor data collection
- Planned expansion to provide analog functionality (ADC and DAC)

Status
- Data Sheet available at www.americansemi.com
- FleX-MCU available early Q4 2013

Announced at LOPE-C
June 13, 2013
**Features**

- 8-bit Successive Approximation ADC
- 8 input channels and 100k samples/s
- Single, continuous, and scan modes
- 2-wire I²C communication
- 2.5V operation
- Manufactured in Jazz CS13 process
- Samples available Q4 2013

**Benefits**

- FleX is flexible and conformable
- FleX is 85% lighter than thinned die
- FleX is 95% thinner than a 20-pin TSSOP package
- FleX is 70% smaller in area than a 20-pin TSSOP package
- Pitch is 42% tighter providing more I/O in the same space
FleX-RFIC™
First Wireless Communications IC

- IP-X™ tag-talks-only (TTO) protocol
- Programmable via 2-wire I²C interface
- 860-960MHz (UHF)
- 64-bit unique identification (UID) including 16-bit CRC
- 0.1m–10m read range; depending upon reader power
- 64kpbs or 256kpbs data rates
- Anti-collision protocol supports more than 45 tags/sec
- Manufactured in Jazz CS13 process
- Demonstration samples available Q4 2013

Antenna +

Power-On Reset

Antenna -
FleX-MCU™ Development Kit

- Flexible development kit hardware includes:
  - FleX-MCU on a flexible demonstration board
  - Standard connectors for interfacing to PCs and prototyping boards
  - Flexible, printed display and push-buttons
  - Voltage regulators (conventional)
  - Serial EEPROM (conventional)

- Software and Documentation
  - C-compiler and assembler
  - Product specifications
  - User’s guide
  - Data sheet
  - Demonstration software

- Samples available Q4 2013
Thank You