Flexible Electronics

You’re doing it wrong
Flexible Development Has Focused on Printed Technology

Printed is great for displays and sensors!

However...

Printed transistors are too big for ICs
Printed transistor dimensions are measured in microns; semiconductors are measured in nanometers

Printed transistors are not dense
Dense printed transistors are measured in tens or hundreds; ICs are measured in millions

Printed transistors are not fast

Printed transistors are not low power

Traditional Semiconductors Are Not Compatible with Printed/Flexible

ICs are great for processors, memory, and SoCs

However...

Packaged ICs are relatively large
ICs are thick and too big for flexible systems

Packaged ICs do not bend or conform
ICs are not designed for flexible electrical or mechanical connections

ICs are not flexible
Silicon IC die are fragile and not physically flexible

ICs are not suitable for large areas
The cost per area of silicon is high
Flexible Hybrid Systems Span Multiple Markets

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

Printed Electronics
- Sensors & Displays
- Low Cost
- Large Format
- Roll-To-Roll or Screen Print

Bio Medical:
- Body Worn
- Monitoring
- Health & Safety

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

Automotive/Aerospace:
- Conformal
- Structural Integration
- Sensors
- Fly-by-Feel

Consumer:
- Tablets
- Phones
- Wearable
- TVs
- Gaming
- Toys

FleX-ICs
- Logic, Memory, Signal Processing, Communications
- Physically Flexible CMOS
- High Performance
- High Density
- Compatible with Printed Electronics

Image courtesy MC10

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LG Chem has curved batteries in production, ready for 'phones, watches and glasses'

LG Chem, a leading battery manufacturer, is ready to unveil batteries that have not existed before. The types of LG Chem’s future batteries can be categorized as the following. Stepped Battery, Curved Battery and Cable Battery.

LG confirms production of 'bendable and unbreakable' smartphone displays

"The flexible display market is expected to grow quickly as this technology is expected to expand further into diverse applications including automotive displays, tablets and wearable devices.,” said Dr. Sang Deog Yeo, Executive Vice President and Chief Technology Officer of LG Display.
**PRODUCTS** are what our industry needs
Products require concept demonstrations
Capability is needed to enable product development

*New Technology: 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.

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

ZIF Connector
Ribbon Cable
State of the Art
Flexible Hybrid Assembly

• Semiconductor IC – FleX-ICs™
  (Mechanical Die used for development)

• Printed Substrate - PET

• FHS – Die Attach
  • Challenge: Full adhesion with ≤ 75um alignment tolerance

• FHS – Die Connect
  • Challenge: Pitch ≤ 260um, Min Feature ≤ 130um
  Pad Up (Conductive Adhesive)
  Flip Chip (ACA)

ACA – Anisotropic Conductive Adhesive
**ASI Rainbow™ FCB Test Coupon with MEC Die**

- **Pad-up Configuration**
  - Resistance measurement from point1 to point2 is \(~30\)Ω
  - Resistance of substrate traces from edge to near the mechanical die are 14-15Ω (red/blue)
  - Resistance of die region (green) which consists of two pad-to-trace interconnects and a printed trace on the mechanical die, are in the 0.2-1.5Ω range
  - Resistance between adjacent traces are >10MEGΩ

- **Flip-chip Configuration**
  - Die region on flip-chip board consists of two pad-to-trace contacts made with anisotropic ink/paste and a printed trace on the mechanical die; this (green) section has a resistance of 0.2-1.5Ω
  - Resistance between adjacent traces are >10MEGΩ
Flip-chip
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
Flexible Electronic Products and Services

- 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 FleX operations
- Small Business
- Privately Held
- Founded November, 2001

Product Lines
- FleX™ – Silicon-on-Polymer™ (Flexible ICs)
- Design Services – Turnkey Design Solutions

Beginning Aug 2014 ASI is moving!
FleX™ Silicon-on-Polymer provides the flexible solution we need TODAY.

- FleX – 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
FleX-IC™ and FHS Product Roadmap

FleX-LNA™ Low Noise Amplifier

FleX-MCU™ With FleX-ADC and FleX-NVM onboard

FleX-ASIC Custom IC

FleX-NVM™ Non-Volatile Memory

FleXform 2 Flexible Hybrid System Development Kit

FleXform 1 Flexible Hybrid System Development Kit

FleX-RFIC™ 860-960MHz (UHF) IP-X™ TTO RFID

FleX-ADC™ 8-bit Analog-to-Digital Converter

FleX-MCU™ 8-bit RISC, 1.2V core, 2.5V I/O, 8K SRAM, UART, I2C, SPI; Sampling 2014
Thank You

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