Enabling Electronic Devices, Materials, and Processes with Physically Flexible ICs

Rich Chaney
Traditional “Crunchy” (rigid)  Flexible
Samsung Galaxy Gear

Pebble

Artistic Concepts

Image credit: Todd Hamilton
Launched June 29, 2007

6.1 million units in 1st five quarters

By 2010 had 4% market share with more than 50% of total profit
“Curved-screen smartphones are a solution looking for a problem”

“From a usability point of view, they don't really give much”

“I can’t see anything that makes me want to move to a curved screen from a flat screen”

LG G Flex announced with vertically curved 6-inch 720p screen

LG’s unveiled all the details for its often-leaked, curved screen smartphone. In comparison to Samsung’s Galaxy Round, the screen on the G Flex arcs from top to bottom, not side-to-side, which at least makes a little more sense to us, hopefully fitting in better to the curvature of the users’ face.

Samsung Galaxy Round hands on

We only found one application that takes advantage of the Galaxy Round’s unique shape, which is the “Roll Effect” notification display. When the phone's on standby and facing upwards on a table, you can take a quick peek at the time, date, number of missed calls, number of unread messages and battery level by simply holding down one side of the phone.
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.

The Ecosystem for Flexible Devices Exists Now!

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.

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.
Printed Electronics Not Suited to ICs

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
ICs for processors, memory, and SoCs must meet current and future consumer demands for functionality

Printed transistors are not low power
Consumers demand battery life

Integrated Circuits v. Printed Transistors
Orders of magnitude faster, at lower voltage!
Traditional ICs Not Suited to Flexible

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
FleX ICs can be used to create Flexible Hybrid Systems

Printed Electronics
- Sensors & Displays
- Low Cost
- Large Format
- Roll-To-Roll (R2R) or Screen Print

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

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

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

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

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

 Image courtesy MC10
FleX-IC™ Product Roadmap

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

FleX-ADC™: 8-bit Analog-to-Digital Converter, 100k samples/s, I2C, 2.5V; Sampling 2014

FleX-RFIC™: 860-960MHz (UHF) IP-X™ TTO RFID, 64-bit UID, 0.1m–10m range, Sampling 2014

FleX-LNA™: Low Noise Amplifier

FleX-NVM™: Non-Volatile Memory

FleX-ASIC: Custom IC

Adds NVM

With FleX-ADC and FleX-RFIC onboard

Chipset for flexible product demonstration

In Process | In Development | Planning

Rich Chaney

2/5/2014
FleX-MCU Testing
Flexible Hybrid System Demo
FleX-IC Chipset for Product Demonstration

**FleX-MCU™**

**Product Overview**
- LP-MCU, ~2.2M transistors
- Designed for SoP
- Physically flexible & conformal

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

**Available in 2014**

**FleX-ADC™**

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

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

**Available in 2014**

**FleX-RFIC™**

**Product Overview**
- IP-X™ 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
- 64kpbs or 256kpbs
- Anti-collision protocol

**Available in 2014**

**FleX-ASIC™**

Your Design as a Flexible IC

**Product Overview**
- MPWs in TowerJazz CS18/13
- High Volume Production
- Design Engineering and Support

**Traditional Silicon Proven IP**
- Digital standard cell library
- SRAM
- Via-programmable ROM
- Power-on-reset controller
- Bandgap voltage ref. generator
- On-chip oscillator

**Soft Silicon Proven IP**
- 8-bit RISC CPU with interrupt controller
- SPI
- I²C
- Real-time clock
- Timers with PWM

**Available Now**

Rich Chaney
Thank You!