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Advanced Flexible Hybrid Electronic (FHE) Demonstrators

November 2018

Printed Electronics USA

Doug Hackler
President & CEO
American Semiconductor

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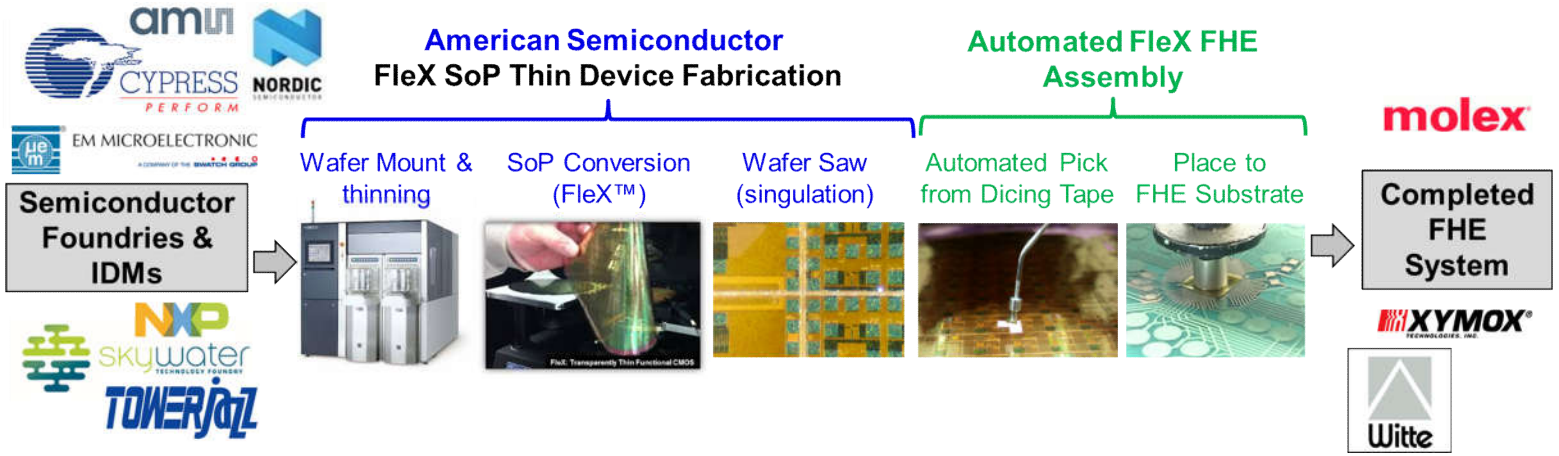
Changing Your World One Flexible Chip at a Time

- American Semiconductor is an industry leader in CSP technology
- Semiconductor-on-Polymer (SoP) CSP is ultra-thin and flexible



- SoP CSP ICs (FleX-ICs™) are available today
- SoP CSP is available as a service
- SoP support services include system design, substrate procurement, assembly and test

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Chip Scale Packaging (CSP) - Defined

- "In the past, CSP's have been defined as a package that is 1.2X the size of the die. However, some types of CSPs maintain their package size as the internal silicon die reduces in size as a result of the fabrication lithography process gets smaller (die shrink). This effect changes the package to die size ratio. As CSP's have evolved, the definition has changed to 'near die size packages with a ball pitch of 1mm or less'"

  – Intel 2000 Packaging Databook

- SoP extends CSP package size reduction to less than 1.0X the die size

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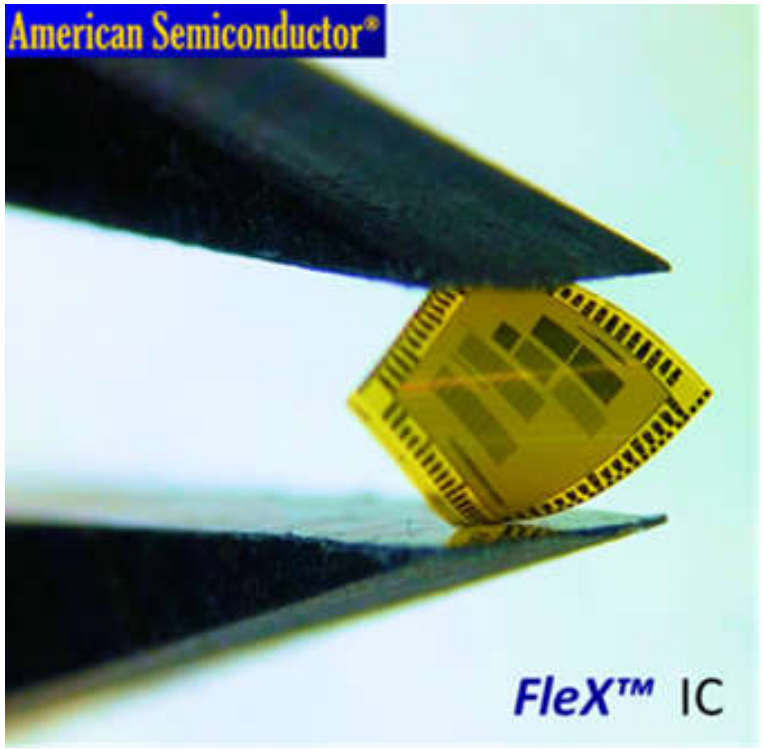
What We Do



Bend it, shape it, anyway you want it, a *FleX* chip makes for limitless possibilities in flexible electronics. Semiconductor-on-Polymer, US Patent 9082881

Semiconductor-on-Polymer (SoP) CSP results in ultra-thin semiconductor materials that are less than the thickness possible with bare die.

SoP was initially introduced to the Flexible Electronics market, the technology has gained interest for conventional low profile, low-mid I/O, DCA type applications.

"FleX" is a trademark for SoP CSP ICs. Not to be confused with flex interconnects.

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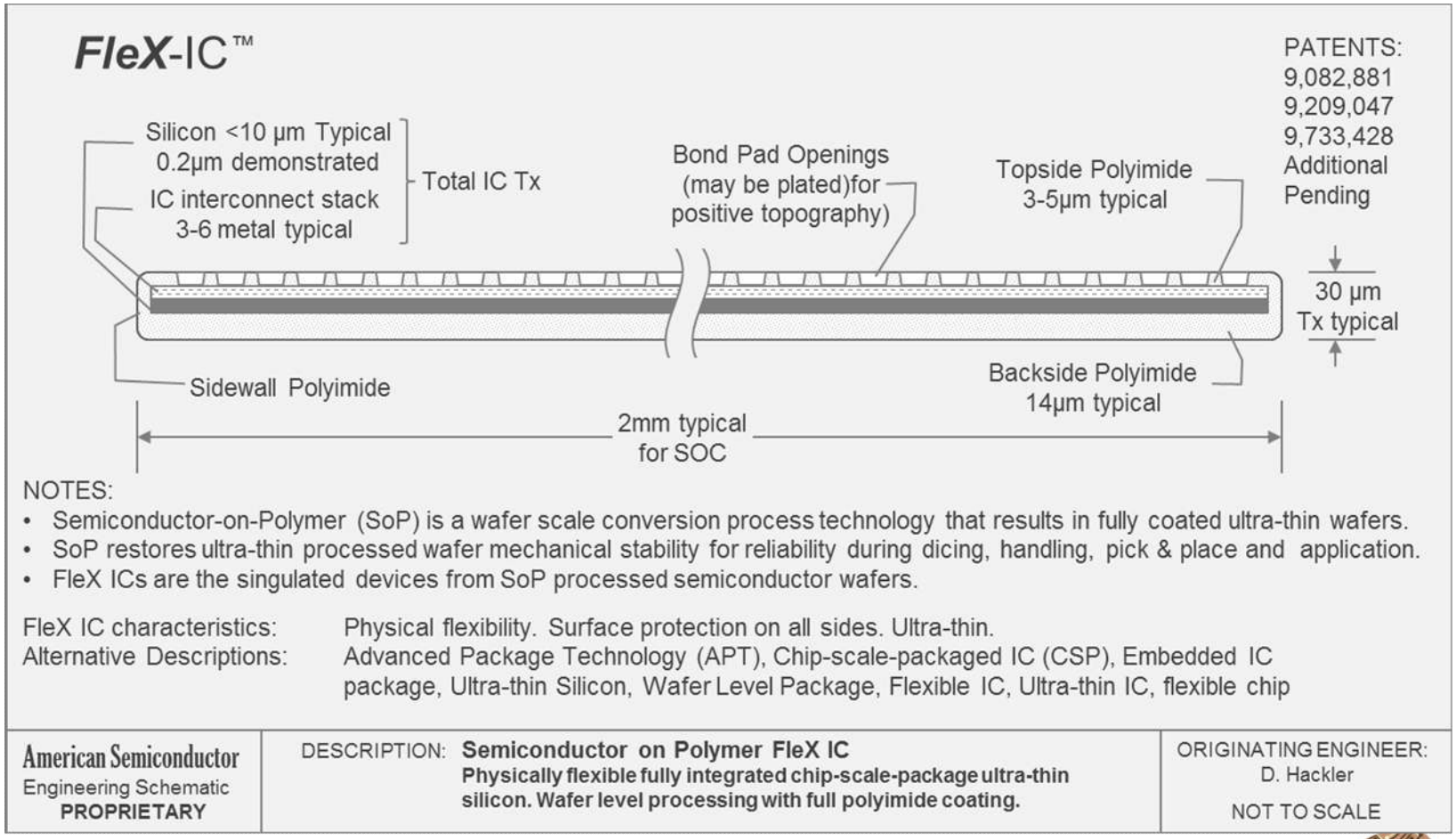
Advanced SoP Chip-Scale-Packaging (ultra-thin)



NOTES:

- Semiconductor-on-Polymer (SoP) is a wafer scale conversion process technology that results in fully coated ultra-thin wafers.
- SoP restores ultra-thin processed wafer mechanical stability for reliability during dicing, handling, pick & place and application.
- FleX ICs are the singulated devices from SoP processed semiconductor wafers.

FleX IC characteristics: Physical flexibility. Surface protection on all sides. Ultra-thin.

Alternative Descriptions: Advanced Package Technology (APT), Chip-scale-packaged IC (CSP), Embedded IC package, Ultra-thin Silicon, Wafer Level Package, Flexible IC, Ultra-thin IC, flexible chip

American Semiconductor Engineering Schematic **PROPRIETARY**	DESCRIPTION: **Semiconductor on Polymer FleX IC** **Physically flexible fully integrated chip-scale-package ultra-thin silicon. Wafer level processing with full polyimide coating.**	ORIGINATING ENGINEER: D. Hackler NOT TO SCALE

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Package Thickness Scaling

Attribute	SOIC-16 (D) [1]	SSOP-16 (DB) [1]	TSSOP-16 (PW) [1]	TVSOP-16 (DGV) [1]	QFN-16 (RGY) [1]	Direct Chip Attach (DCA)[2]	FleX-SoP (SoP) [3]
Length, mm	9.90 ±0.10	6.20 ±0.30	5.00 ±0.10	3.60 ±0.10	4.00 ±0.15	2.51	2.163±0.01
Width, mm	6.00 ±0.20	7.80 ±0.40	6.40 ±0.20	6.40 ±0.20	3.50 ±0.15	2.51	2.283±0.01
Height, Max. mm	1.75	2.00	1.20	1.20	1.00	.075	0.025
Pitch, mm	1.27	0.65	0.65	0.40	0.50	RDL	<0.1
Footprint, mm^2	59.40	48.36	32.00	23.04	14.00	6.3	4.94
Encapsulated	Yes	Yes	Yes	Yes	Yes	No	Yes (PI)
Weight, g	0.150	0.140	0.062	0.040	0.036	~.0008	.00023
SoP area save, %	91.6	89.8	84.6	78.6	64.7	NA	-

1. Quad Flatpack No-Lead Logic Packages, TI Application Report SCBA017D – February 2004 Morton, Wright
2. NHS3100, Bumped Die, NXP Product Data Sheet (NFC-SOC)
3. AS_CY8C20 FleX-SoC Datasheet, American Semiconductor, 2018

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FHE – SoP IC with Direct Interconnect

Hybrid systems provide a flexible product solution that combines the best of silicon based components and flexible organic and printed electronics

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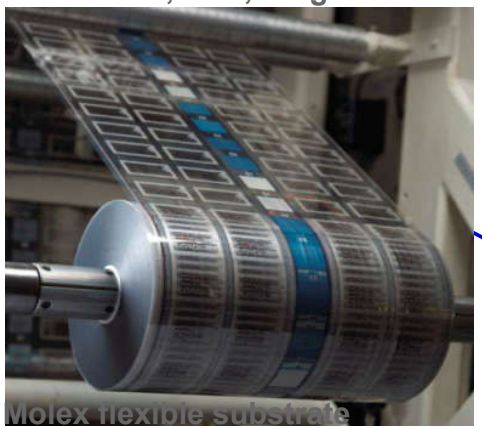
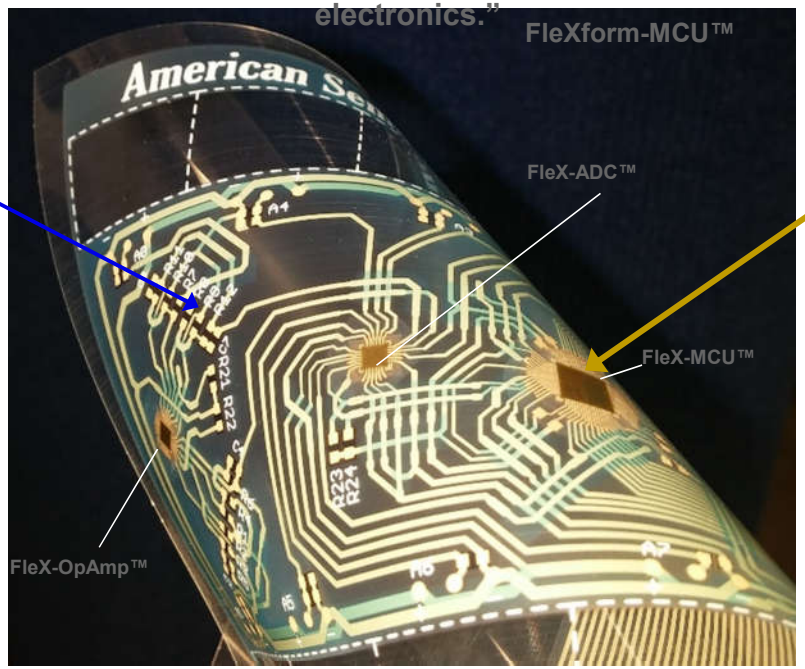
Low Cost, R2R, Large Format



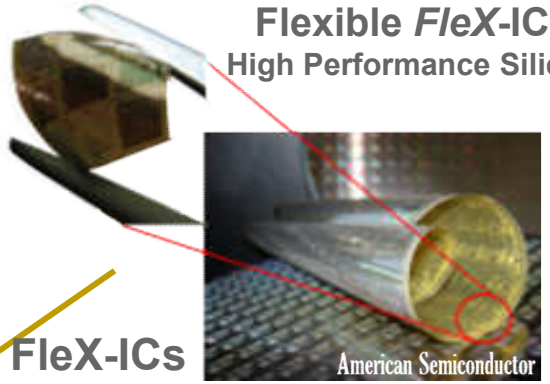
Printed Electronics
- Sensors
- Interconnects
- Substrates
- Displays

- Low Cost, Large Format
- Roll-To-Roll, Screen, Inkjet Print,...

Flexible Hybrid System
Combination of printed materials and high performance components to create a new class – "flexible electronics."



Flexible *FleX*-ICs
High Performance Silicon



FleX-ICs
- **Sensor Signal Processing**
- **Data Processing**
- **Data Storage**
- **Communications**
- **Low Cost, High Performance**
- ***FleX* is a Semiconductor-on-Polymer (SoP) conversion process that results in chip scale packaging.**

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Demonstrators for this presentation - NFC

Product	Description	Datasheet Link
AS_ADC100x	FleX-ADC Analog-to-Digital Converter: 8-channels, 8-bits ASI (TowerJazz Semiconductor Foundry)	Datasheet
AS_ADC2001	FleX-ADC Analog-to-Digital Converter with 3 Configurable Op Amps ASI (TowerJazz Semiconductor Foundry)	Datasheet
AS_CY820x	FleX-SoC (System-on-a-Chip) with Capacitive Sense Cypress Semiconductor PSOC® CY8C20XX6A/S	Datasheet
AS_EM4325P	FleX-RFID 900MHz RFID Communication Temperature Monitoring IC EM Microelectronics EM4325	Datasheet
AS_NHS3100P	FleX-NFC Temp Logging IC with ARM® Cortex-M0+ NXP Semiconductor NTAG SmartSensor with Temperature Sensor	Datasheet
AS_AM39513	FleX-NFC Sensor Tag IC AMS (Austria Microsystems) AS39513 NFC Sensor Tag IC	In Development
AS_OPA4002	FleX-OpAmp Quad High Performance Op Amps ASI (TowerJazz Semiconductor Foundry)	Datasheet
AS_OPA4003	FleX-OpAmp Quad Output Transconductance Op Amps ASI (TowerJazz Semiconductor Foundry)	Datasheet
AS_CY8C424	FleX-BLE Bluetooth Low Energy with ARM® Cortex-M0 Cypress Semiconductor PSOC® 4 Bluetooth LE	In Development
AS_NRF51822	FleX-BLE Bluetooth Low Energy with ARM® Cortex-M0 Nordic Semiconductor nRF51822	In Development

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Advanced FHE Demonstrators

Requirements for advanced FHE demonstrator

1. Hybrid construction – Combining the best of printed and semiconductor worlds
2. Flexible film – Printed PET, PEN, etc. or Cu on Kapton, or other deformable board
3. High performance components – Logic, Memory, Communications, Precision passives, etc.

Additional Preferred characteristics

4. Ultra-thin
5. Flexible in finished format
6. Robust and Reliable

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SoP CSP demonstrated in multiple markets

Consumer
Wearables
Accessories

Wearable Products

- FleX – SOC, NFC, RFID, BLE
- FleX – ADC, OPAMP
- Authentication/Anti-counterfeit
- Consumer data collection
- User customization
- Functional clothing – Heat, Cool, Monitor

Image courtesy: DUPONT

IoT Communication
Sensing
Tracking

IoT

- Smart City
- Smart Home
- Distributed sensing systems
- Mobile commerce
- Asset tracking
- Smart farming

Logistics & Warehousing
Item Tracking
Temperature Tracking
Other sensors

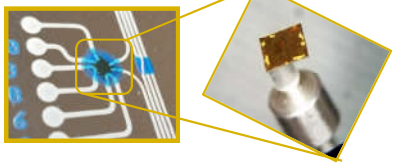
Smart Labels

- FleX – NFC, RFID, BLE
- Wirelessly report sensor data without opening shipping cartons
- Passive tags require no battery
- Active logging tags with flexible battery technology

Healthcare
Bandages
Blood Bags
Clinical Trials
Cold Chain
Personal Health Monitors
Pharmaceuticals
Medical Devices
Vaccines

Patient and Pharmaceutical Data

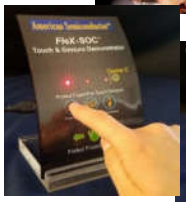
- FleX – SOC, NFC, RFID, BLE
- FleX – ADC, OPAMP
- Wearable monitors and drug delivery
- Remote monitoring
- Embedded Electronics
- Diagnostics
- Environmental
- Medical Equipment
- Consumables
- Smart BioPatch (EKG, Glucose, etc.)

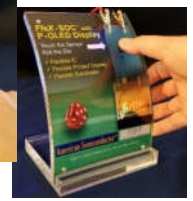


Automotive
Aerospace
White goods
Interiors
Exteriors
Components

Cockpits, Entertainment, Displays, Control Panels, Sensors

- FleX - SOC
- IME (In-Mold Electronics)
- Display Integration
- Smart tires, belts, hoses, fabrics, panels
- Wired and Wireless Sensors





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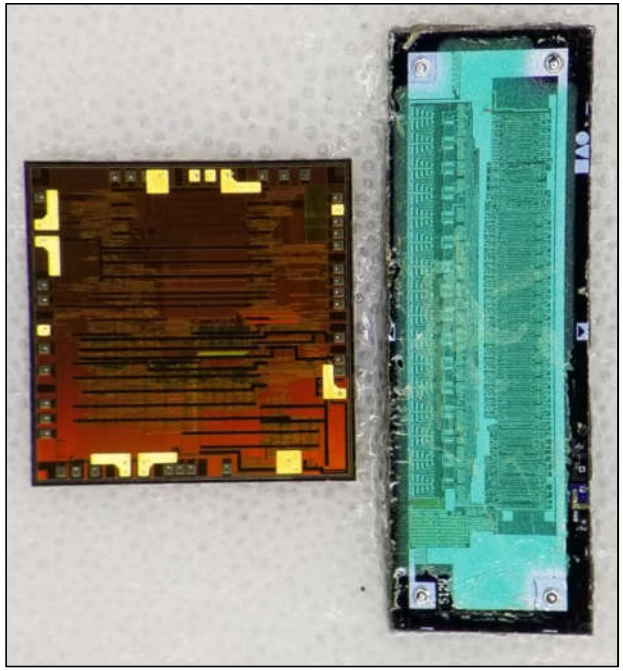
Hybrid Technology Advantage

FleX-NFC

- ✓ Easily flexible
- ✓ Ultra-thin
- ✓ Passive and Active Modes
- ✓ CPU: ARM Cortex M0+
- ✓ Flash: 32768 bits
- ✓ SRAM: 8192 bits
- ✓ EEPROM: 4096 bits
- ✓ Wireless Programming
- ✓ Temperature Sensor
- ✓ Real-Time Clock
- ✓ Data Logging
- ✓ Fully ISO14443A compliant
- ✓ Programmable NFC response
- ✓ Data Integrity: User-programmable
- RF Frequency: 13.56MHz
- Data Transfer Rate: 106Kb/s



Printed NFC

- ✗ Hard to flex
- ✗ Thin
- ✗ Passive Mode Only
- ✗ CPU: None
- ✗ Flash Memory: None
- ✗ SRAM: None
- ✗ ROM: 256-bit Read-Only
- ✗ External Programming: No
- ✗ Temperature Sensor: No
- ✗ Real-Time Clock: No
- ✗ Data Logging: No
- ✗ Subset of ISO14443A
- ✗ Fixed NFC response
- ✗ Data Integrity: 16-bit CRC only
- RF Frequency: 13.56MHz
- Data Transfer Rate: 106Kb/s

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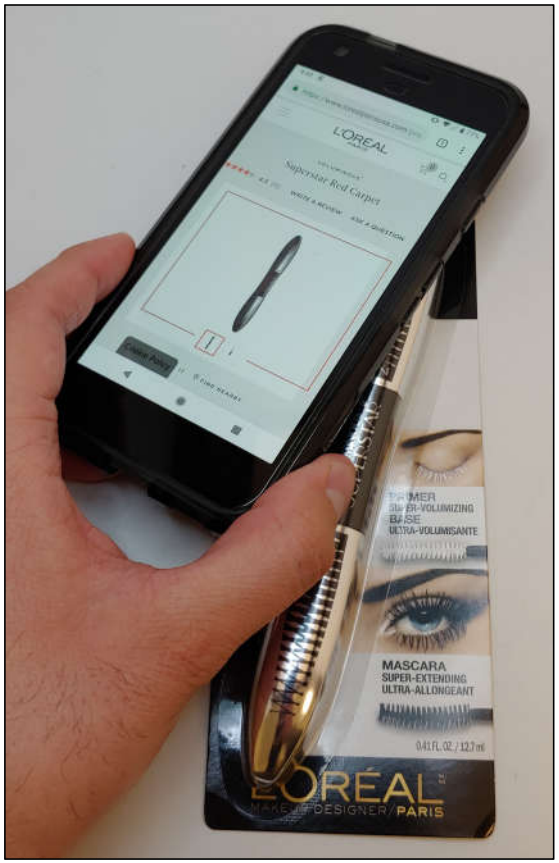
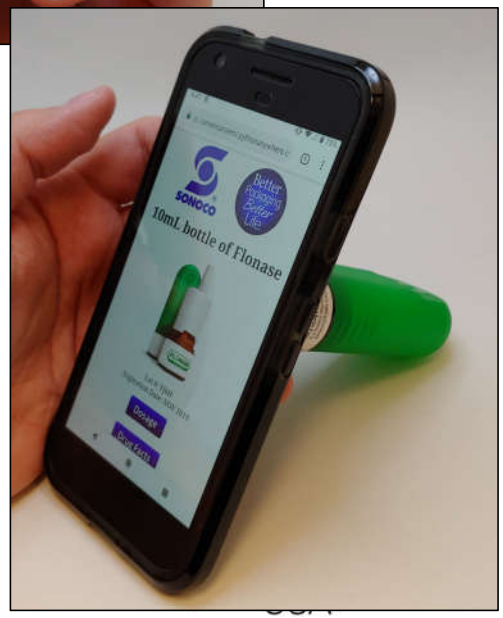
FleX-NFC Enabled Smart Packaging

Features

- Programmable flash memory
- Data storage
- Temperature sensing
- User interaction with websites or custom apps





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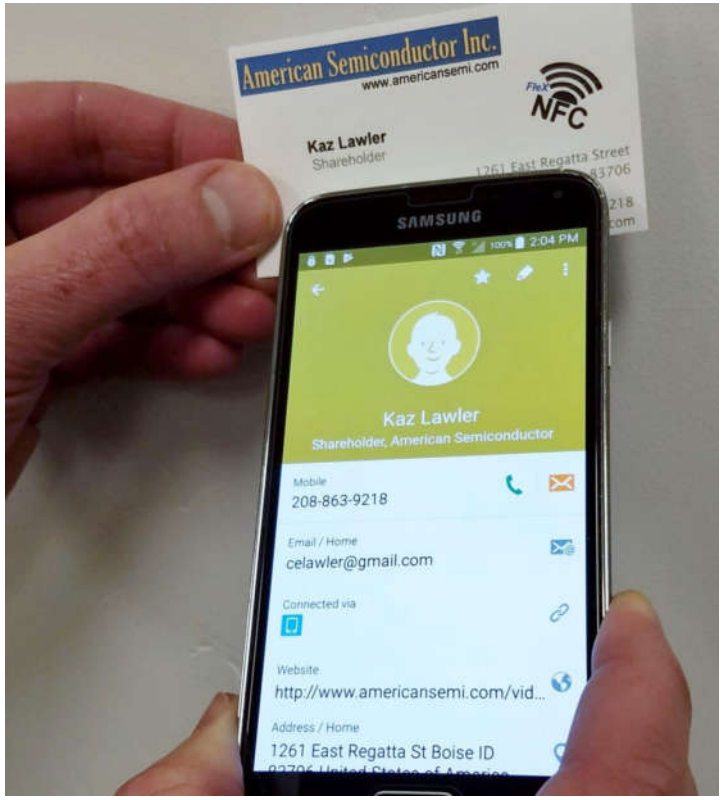
FleX-NFC: NXP NHS3100 Product Demonstrators

NFC Temp Sensing on ID Paper

NFC-Enhanced Business Cards



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FleX-NFC Enabled Authentication

- Unique product authentication
- Anti-counterfeiting and anti-spoofing
- Encryption of device ID
- Rolling codes

Koenig Vineyards

2014 Cuvee Alden Private Reserve

Bottle ID#:
04762fd5005a1838

Bottle Temperature:
20.5°C

Scan Log

Buy Online

✔Bottle Authenticated✔

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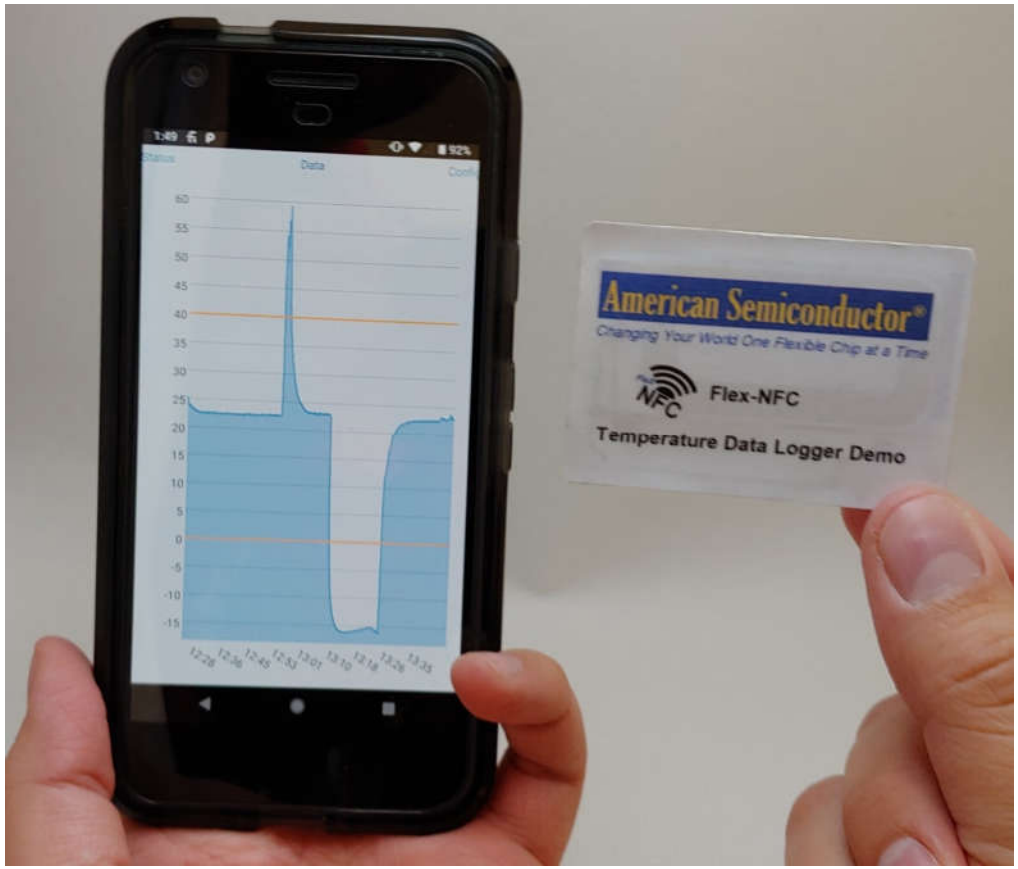
FleX-NFC Enabled Data Loggers

- Features
  - Temperature sensing
    - ±0.3°C between 0°C and 40°C
    - ±0.5°C between -40°C and 85°C
  - Programmable sample intervals
  - Stores up to 22k data points
- FleX-NFC flexible IC
  - Ultra-thin, flexible version of the NXP NHS3100
  - ~35um total thickness
- Flexible Antennas
  - Printed silver on paper
  - Copper on Kapton
- Enfucell SoftBattery®
  - 3.0V
  - 10mAh



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