New Emerging Technologies for Contactless Microsystems

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New Emerging Technologies for Contactless Chips

- Chip and micro systems evolution

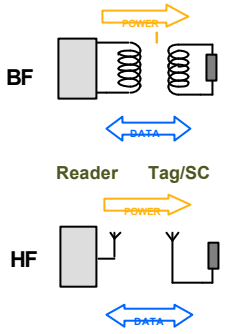
- Improved performances
  - Very High Data Rates
  - Non Volatile Memories
  - High MIPS/low power
  - Multi-Tag flow reading protocols

- New embedded functions for traceability and security
  - Micro sensors
  - Micro batteries

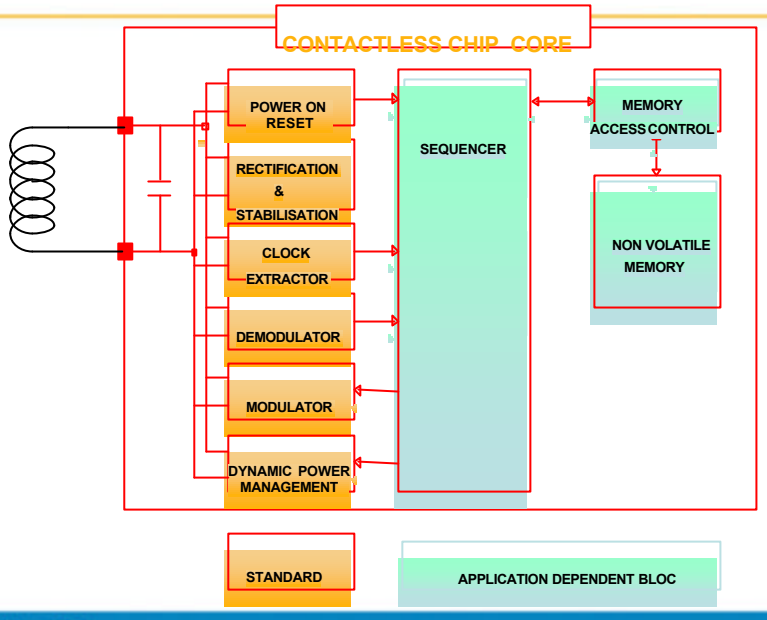
- Low cost process

Introduction to contactless passive/active devices

- Basic Passive Contactless Overview
  - No power on micro system
  - Forward link communication: energy and data transmission
  - Return link communication: passive load modulation
- Future Applications Requirements
  - Very High Data Rates for Smart Cards
  - Very Low Power RFID Electronic Tags
  - Active tags for sensing and security
- Main applications
  - Basic ID: Tags and Smart Cards
  - Typical: Medical or industrial implants



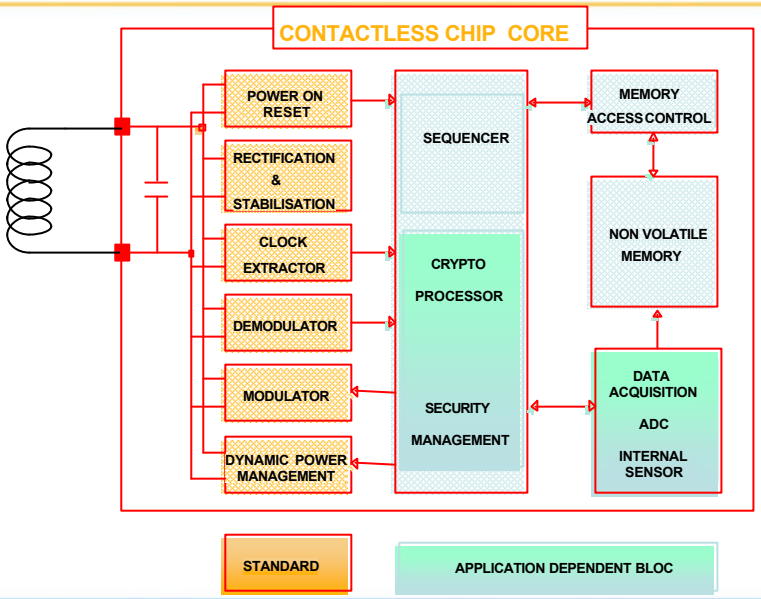
Contactless μsystems : the low cost generation



Very Low Cost

- **RFID**
- **Ticketing**

Contactless µsystems : the secure generation

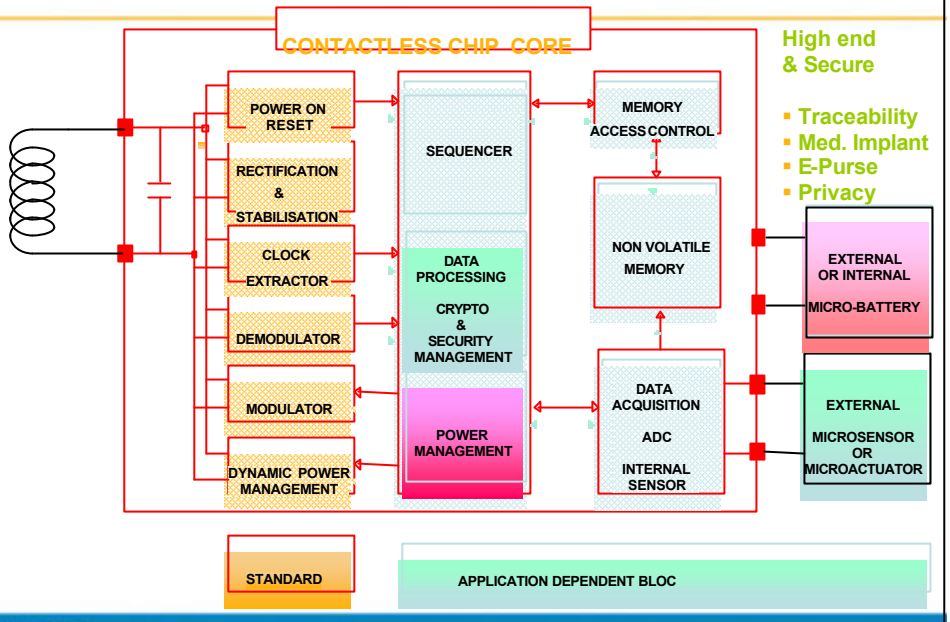


Low Cost

& Secure

- RFID
- Ticketing
- Smart Card

Contactless µsystems : the active generation



High end

& Secure

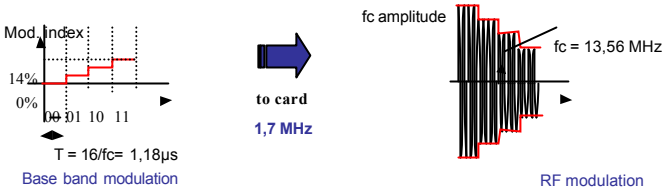
- Traceability
- Med. Implant
- E-Purse
- Privacy

Very High Data Rate Interface

- Technical Goals : Break the 1Mbits/s barrier for Cless SC
  - *An ISO 14443 extension*
  - *Scalable kbps: 106, 212, 424, 847 → 1700 → 3400 → and beyond*
  - *Same antennas bandwidth for all data rates*
  - *Low cost upgrade*
- One bit to multi bit per symbol → Multi-level modulations
  - ✓ *Reader → Card : Multi level ASK modulation*
  - ✓ *Card → Reader : Multi phase PSK modulation on sub-carrier*
- First step :
  - *Validation of reader and smart card chip air interface at 1.7Mbps*
  - *Technical proposal to standardisation committee*

Very High Data Rate Interface

- From PCD (reader) to PICC (card)
  - Multi-levels Amplitude modulation on carrier frequency



  - Data rate = f (nb levels, T symbol) = log2(nb_level)/T

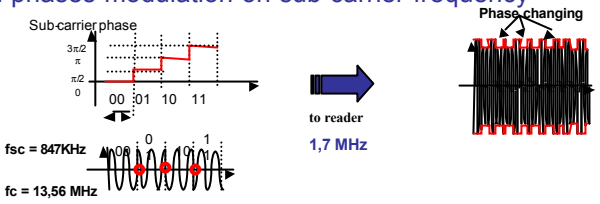
	2 levels : 2^1	4 levels : 2^2	8 levels : 2^3	16 levels : 2^4
T = 128 /fc (9,4 µs)	106 kbits/s	212 kbits/s	318 kbits/s	424 kbits/s
T = 64 /f c (4,72 µs)	212 kbits/s	424 kbits/s	636 kbits/s	848 kbits/s
T = 32 /f c (2,36 µs)	424 kbits/s	848 kbits/s	1271 kbits/s	1695 kbits/s
T = 16 /f c (1,18 µs)	848 kbits/s	1695 kbits/s	2542 kbits/s	3390 kbits/s

1.7 Mbps

x 2^n

Very High Data Rate Interface

- From PICC (card) to PCD (reader)
  - Multi-phases modulation on sub carrier frequency



  - Data rates = f (nb phases, T symbol) = log2(nb_phases)/T

	2 f : 2^1 180 °	4 f : 2^2 (90°)	8 f : 2^3 (45°)	16 f : 2^4(23°)
fs = 848 kHz				
T = 2Ts (2,36 µs)	424 kbits/s	848 kbits/s	1271 kbits/s	1695 kbits/s
T = 1Ts (1,18 µs)	848 kbits/s	1695 kbits/s	2543 kbits/s	3390 kbits/s
fs = 1,7MHz				
T = 2Ts (1,18 µs)	848 kbits/s	1695 kbits/s	2542 kbits/s	3390 kbits/s
T = 1Ts (0,59 µs)	1695 kbits/s	3390 kbits/s	5085 kbits/s	6780 kbits/s

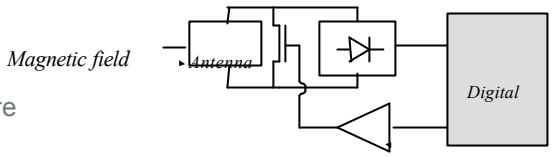
1.7 Mbps

x 2^n

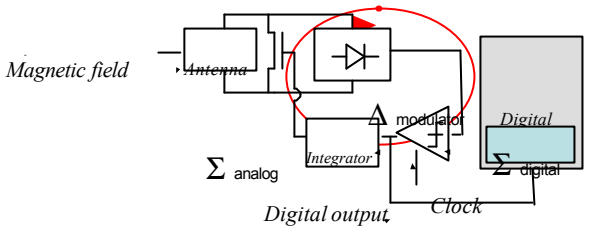
Very High Data Rate Interface

- New demodulator architecture for chip receiver
  - Delta modulator into analogue regulation loop
  - Sigma-Delta converter for RX

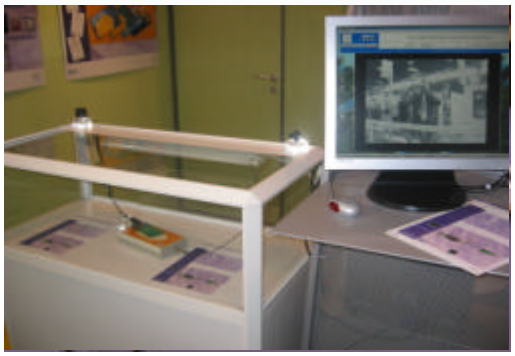
- Classical architecture
  Open loop

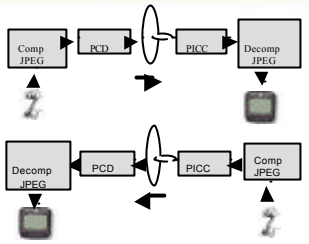


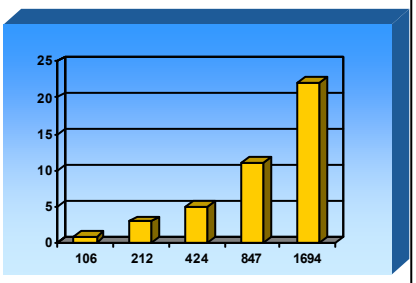
- New architecture
  Closed loop



Very High Data Rate Interface







Frames per second / data rates

- Demonstrator for VHDR:

Forward and return video transfer from 106 kbps up to 1,7 Mbps

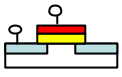
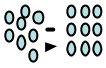
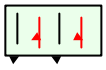
Air interface performances : H = 2,3 A/m and DR = 1,7 Mbits/s
PCD to PICC link : **BER = 10^{-7}** PICC to PCD link : **BER = 10^{-9}**

Non Volatile Memories

Memories challenges for contactless

- Very fast write time (close to read time)
- Low power
- Large storage
- Secure

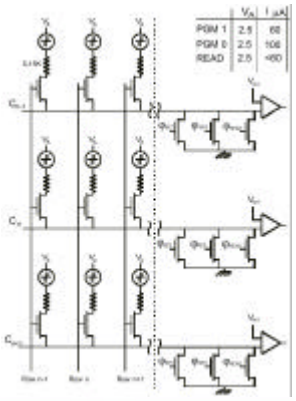
Non Volatile Memory Families

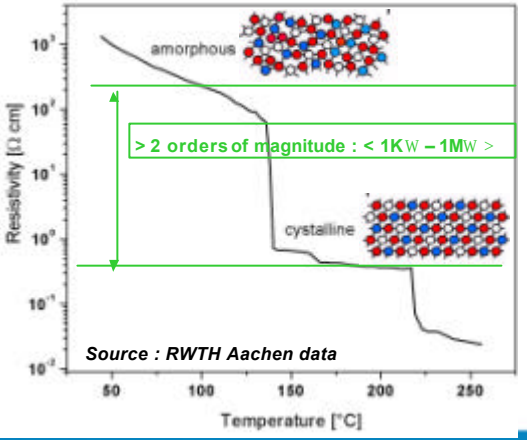
DIELECTRIC	PHASE CHANGE	MAGNETIC	POLYMER	MEMS
				
Flash – NOR NAND F-RAM ; SET	PC-RAM	M-RAM	Molecular	Mechanical Bi stable

Non Volatile Memories: PC-RAM

NVM : Phase Change RAM (from CD/DVD-RW optical disks)

- Phase-Change Alloy Material → High Resistivity Change
- Very High Density
- Radiation Resistant

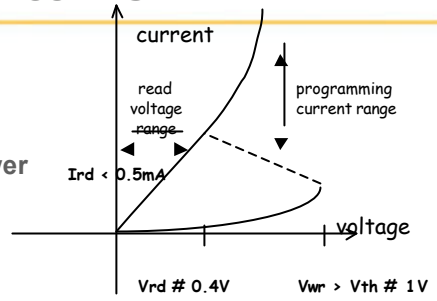


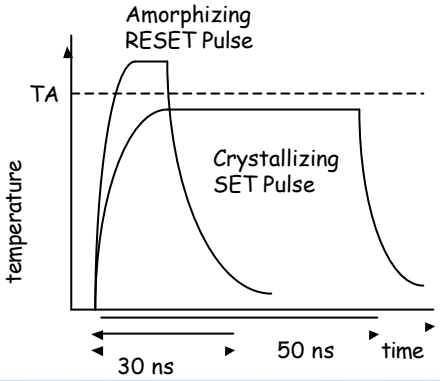


Non Volatile Memories: PC-RAM

NVM : Phase Change RAM

- Ultra Fast RD/WR
- Very Low Programming Power
- Very Low RD/WR Voltage

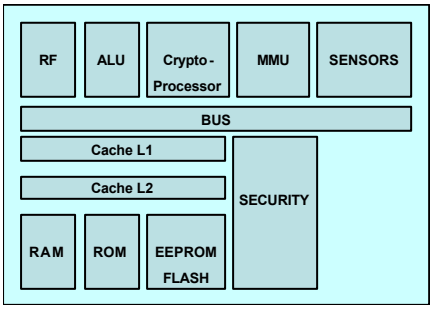


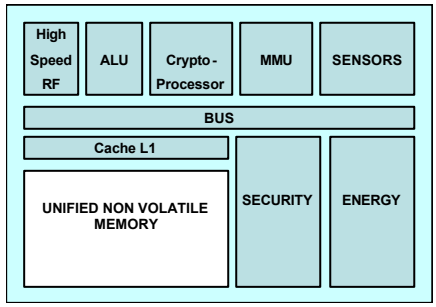


- RD / WR Time : 20 / 30-50 ns
- Cycles count : > 10^{12}
- RD / WR Voltage : 0.4V / 1V
- No Charge Pump
- Bit/Byte/Word Write

Source : Intel Corp.

Non Volatile Memories: CPU Evolution





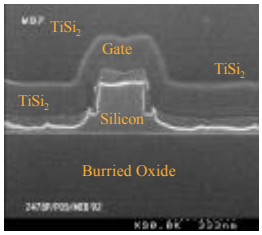
TODAY : µP → TOMORROW : µSoC

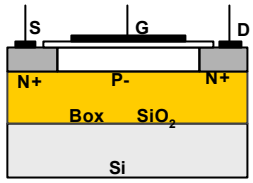
Fast and Low power NVM for contactless CPU core

- Only one type of memory technology (few 10MHz)
- Flat memory for programming model

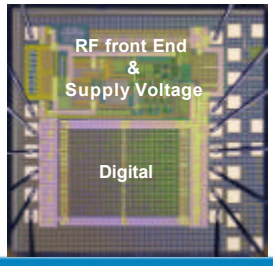
High MIPS / Low Power

Chip Technology : Silicon On Insulator





Insulator layer



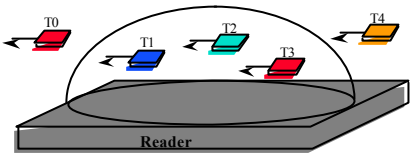
RFID SOI chip

- Low Power
- Low Voltage
- High Speed
- High Isolation

MultiTag Reading & Anticollision

Protocol Characteristics

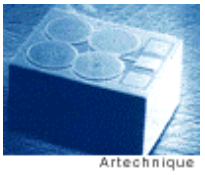
- Determinist Algorithm Characteristics
  - Known Duration: T_{read} = f (Nb Tags, Code Length, Data rate)
  - N-ary Tree Search Algorithms
  - No Random Generator

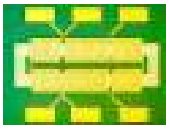


- Flow management
  - First In - First Read Tag (Timer Header + ID Code)
  - Short Address for Fast Access (8bits for 256 tags)

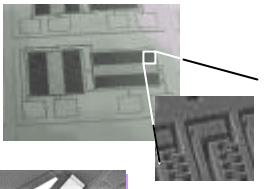
Micro-Sensors

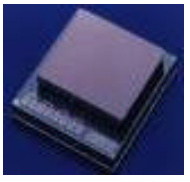
- ✓ Accelerometer
- ✓ Gyro meter
- ✓ Magnetometer
- ✓ Pressure

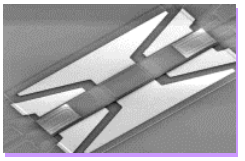




- Low power sensors
  - Capacitive
  - High impedance





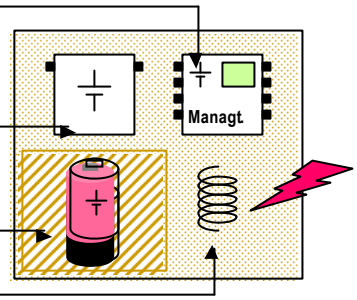


- Micro-packaging
- Micro-switch

Permanent Active Data Monitoring

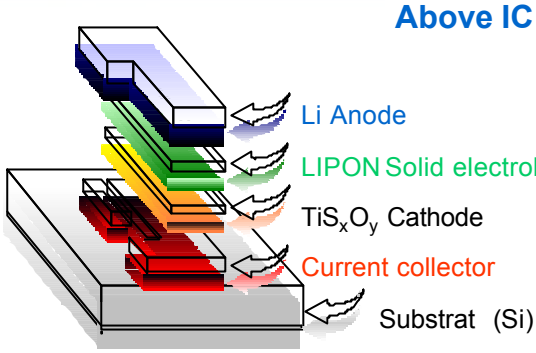
Micro-system Global Power Management

- **Embedded micro-battery**
  (Continuous powering of secure functions)
- **Thin film battery bloc**
  (Temporary powering and back up)
- **External powering**
- **Contactless powering**
- **Embedded battery back up blocs**
  - **Low power clock**
  - **Back up SRAM**

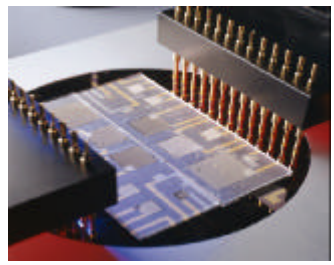


Above IC Micro battery

Above IC Process



Above IC micro battery prototype



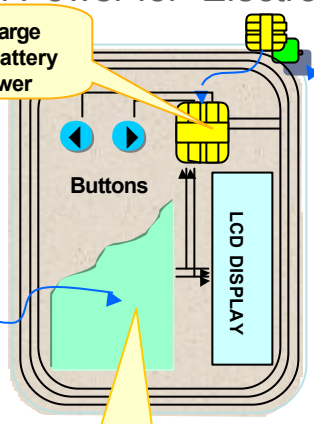
Permanent Active Security : e-Purse

Global Power for Electronic Purse

µ-Battery Recharge
- External Thin Battery
- Contactless Power

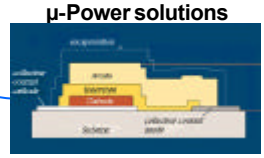
Thin battery

- Thickness < 0.4mm
- Voltage > 2Volts
- Size 2.2 x 2.9 cm²
- Flexible
- Rechargeable < 3 mn
- Energy 20 mAh



Thin Battery Recharge
- Contactless Power

µ-Power solutions

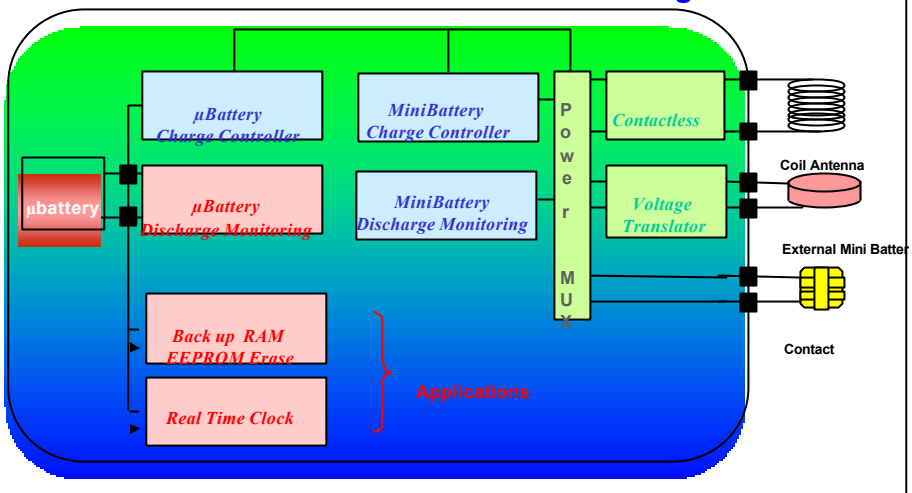


- Above IC Micro-Battery
- Chip
- Energy management

- µBattery
  - Thickness : 10 µm
  - Capacity : 100 µAh/cm²
  - Discharge peak: 1 mA/cm²
  - No internal discharge

Permanent Active Security: Ultra Low Power

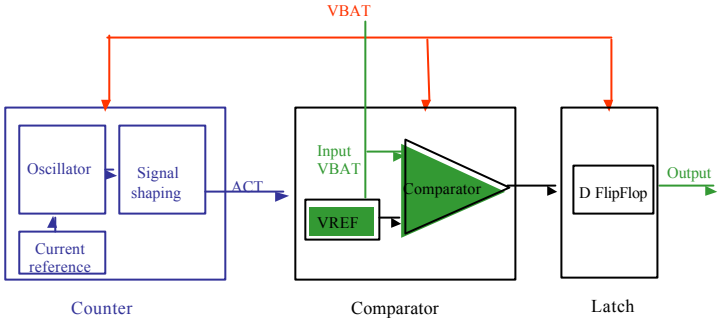
Contact/contactless Global Power Management



- Low Power Functions
- Ultra Low Power Functions

Permanent Active Security: discharge monitoring

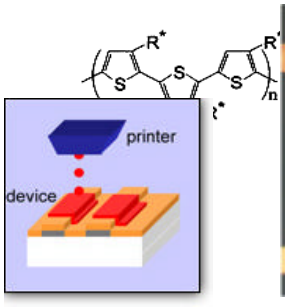
- ***Ultra low power voltage threshold monitoring***

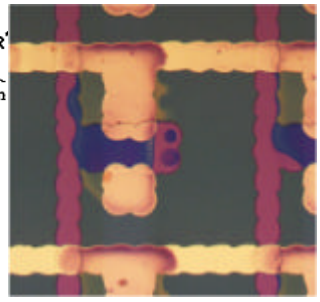


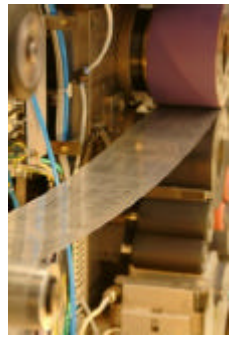
bloc	Current ref.	Oscillator	ACT signal	Comparator	Latch	Total
specs		1Hz	Pulse rate: hour	1,6V +/-30mV		
power	2,4nA	0,49nA	0,42nA	Active 16nA Idle : 0,14 nA	0,1 nA	~20nA ~4 nA

Polymer Electronics

- Printed polymer electronic

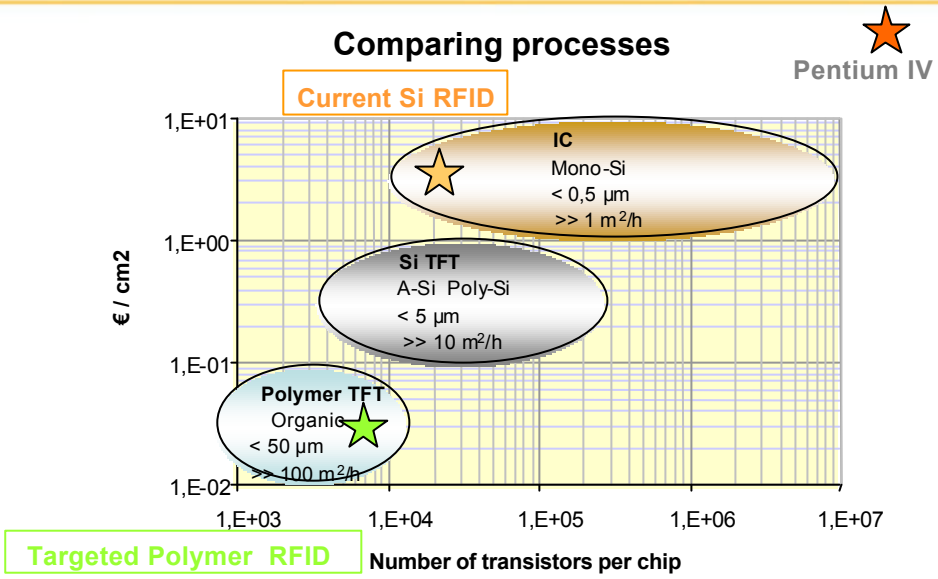






- Printing process
  - On flexible foil
  - Additive techniques
  - Rotary press or Ink jet

Polymer Electronics



Conclusions

- ***Next step of road map***

RFID Evolution	Basic Technologies				
Functions	**VHDR**	**NVM**	**HM/LP**	**µSensors**	**µBattery**
Fast transaction					
Traceability					
Security					
Privacy					
Process evolution					
Si Process impact					
Polymer priorities					

Thank you for your attention

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