# ActiveRFID: Towards a Self-Powered Wireless Sensing Platform

Mervin John, Jesse Richmond, Louis Alarcon, Wen Li, Tsung-Te Liu, Wenting Zhou, Kimiya Hajkazemshirazi, Kenichi Agawa, Michael Mark, Massimo Alioto, Seth Sanders, Jan Rabaey

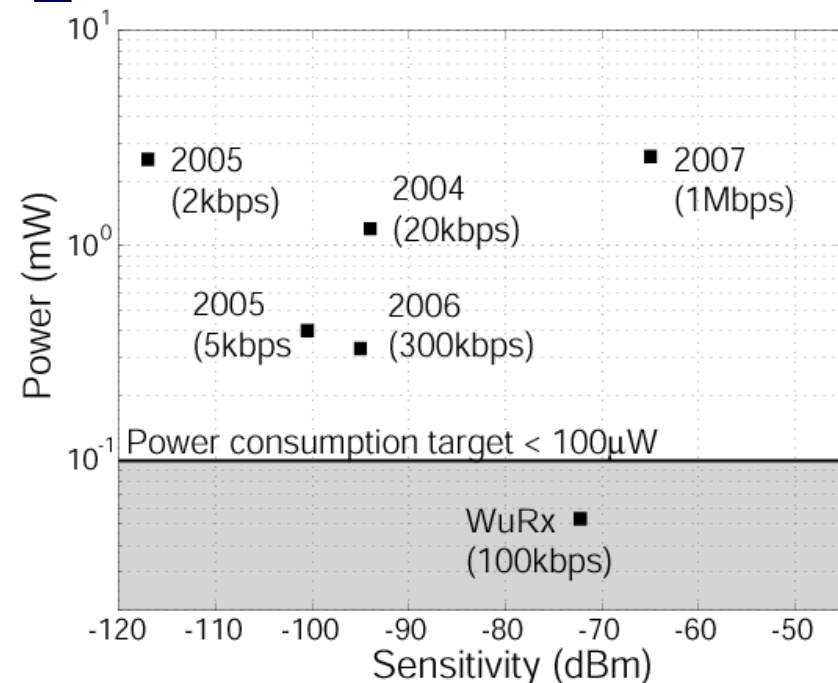# Wireless Sensing – Today

◉ Wireless sensor networks:

- Cost, size and power consumption goals for single devices within technology reach

- Communication distances from cm's to 10's of meters
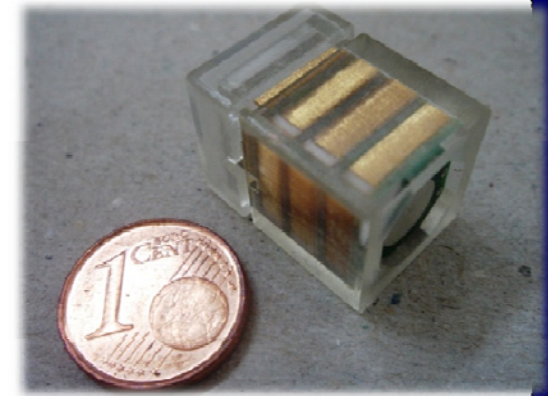
UCB PicoCube

◉ Drawbacks:

- Need network support to be functional – causes major deployment and reliability issues
- Energy still a major issue

"Self - Contained" Active RFID

☐ Combines advantages of WSN & passive RFID tags:

- With power source, enable interrogation from distances >10m

- Compatible with existing RFID protocols

- Easy deployment, low cost, secure…

☐ Opens the door for new applications:

- Enables querying for portable
  mobile devices (e.g. cell phone)
  or from a deployed network (WiFi)

☐ Tag is self-contained, harvesting energy from
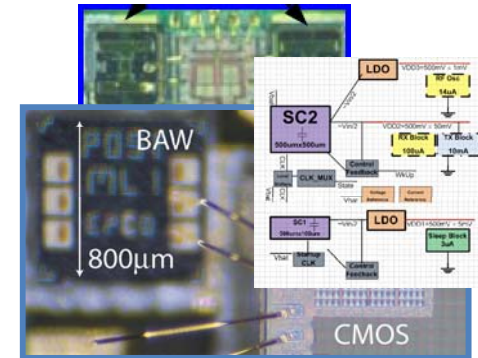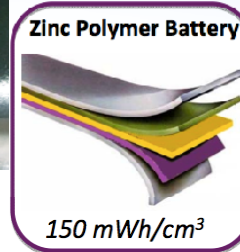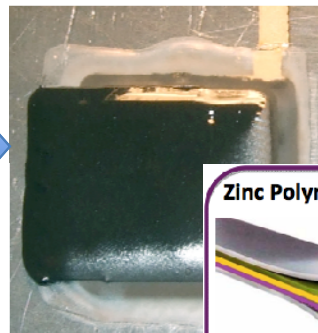 solar cell.
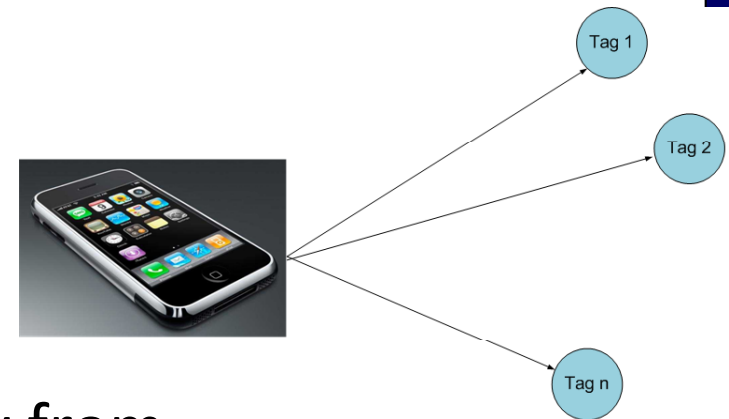
Specifications (Target)
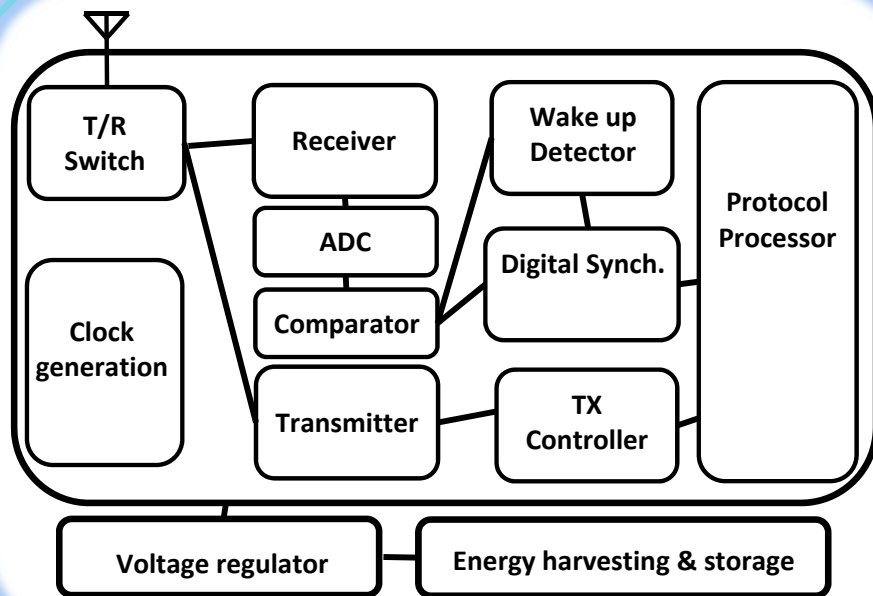
- Fully integrated
- Postage stamp size
- Communication range >10 m
- Datarate of 100 kbps
- Compatible with RFID link and MAC specification

- Can operate indefinitely (for 24 hours/day) from single solar cell – average power dissipation on the order of µWs

Enables querying from portable mobile devices (e.g. cell phones), or from a deployed network

Powering the Active RFID

- Self-powered Active RFID Tag
  - ***Self-contained*** (postage stamp footprint but only mm's thick)
  - ***Fully integrated*** IC (single die)
  - ***Small solar cell*** harvests enough energy for 24 hour operation

Zinc Polymer Battery

150 mWh/cm³

BAW
800µm
CMOS

Solar Cell
- 2cmx1cm
- **10µW** avg (Indoor)
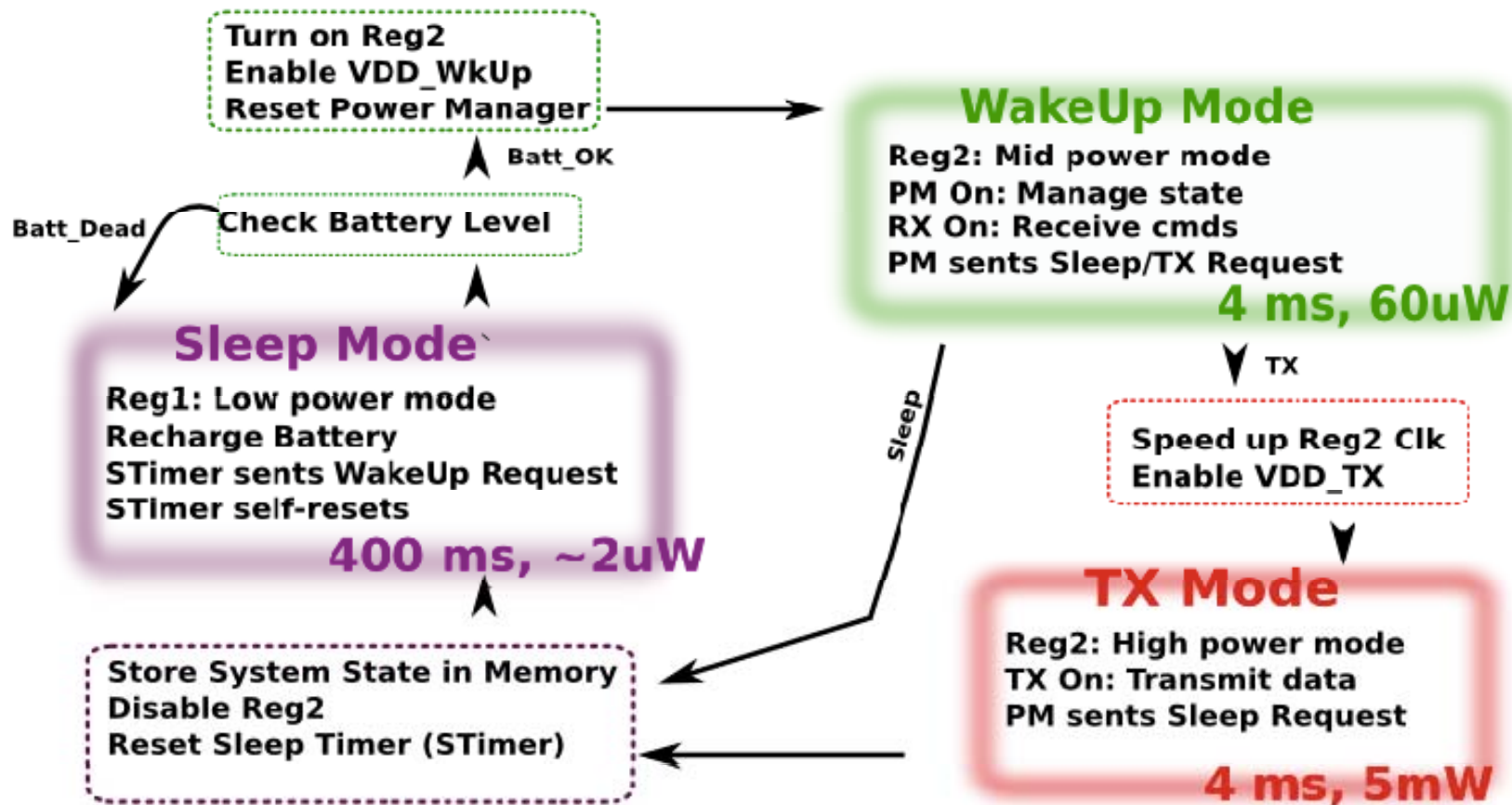- V_{oc} = **2.4V**, I_{sc}=10uA

Printed Battery
- 1cmx1cm
- V_{bat} ~ **1.1-1.8V**
- Integration w/ substrate

Loads (on Single Die)
- 50 µW RX
- 1mW TX
- **0.5V** Logic
- On-chip power management

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pier
PUBLIC INTEREST ENERGY RESEARCH
"Research Powers the Future"

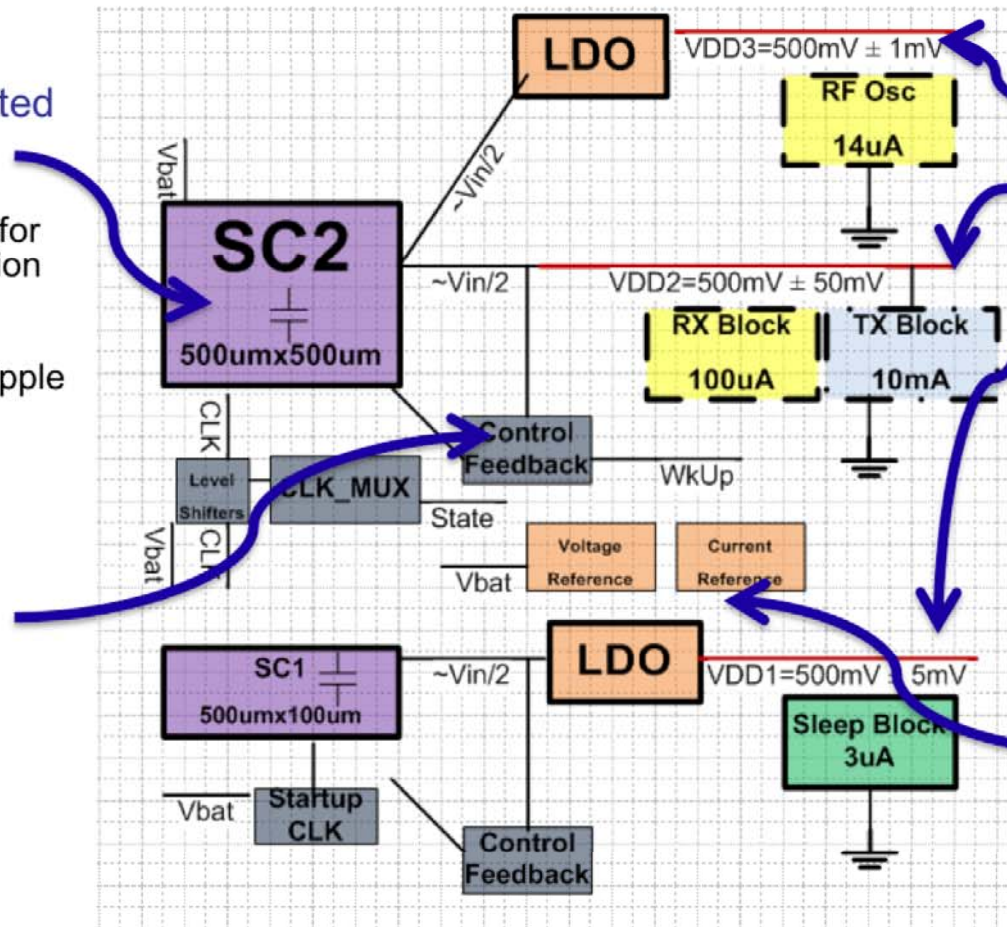# System Power Modes

3 orders of magnitude difference within power!

Integrated Power Management

On-Chip Integrated Caps
- ~0.3mm^2
- Multi-topology for coarse regulation
- Multiple cells interleaved to reduce clock ripple

Control Logic
- Regulation Scheme
- Dynamic frequency & switch Scaling

Multiple Supply Rails
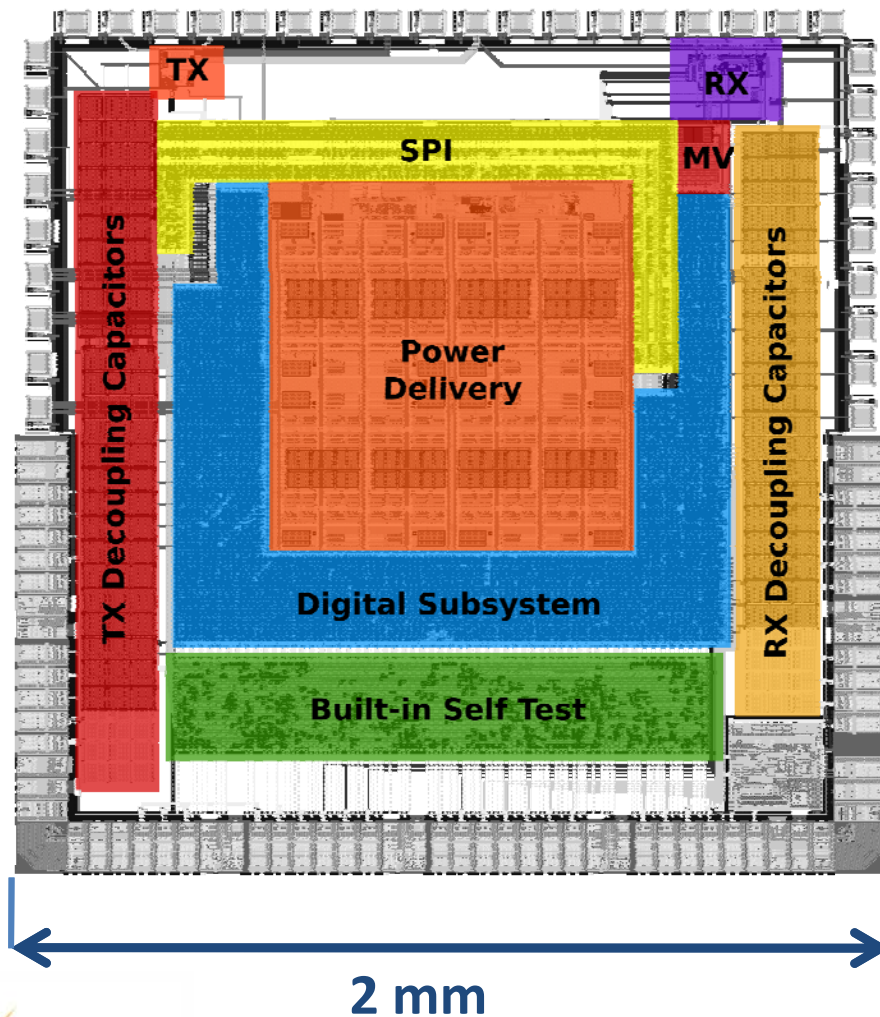- 500mV V_{dd}
- Ripple, Current specs vary

Multi-Mode Operation
- Blocks turned off to reduce leakage/ standby current
- Wide output loads (3uA->100uA->10mA)

Analog Blocks
- Voltage & Current references
- Low-dropout regulator for finer regulation
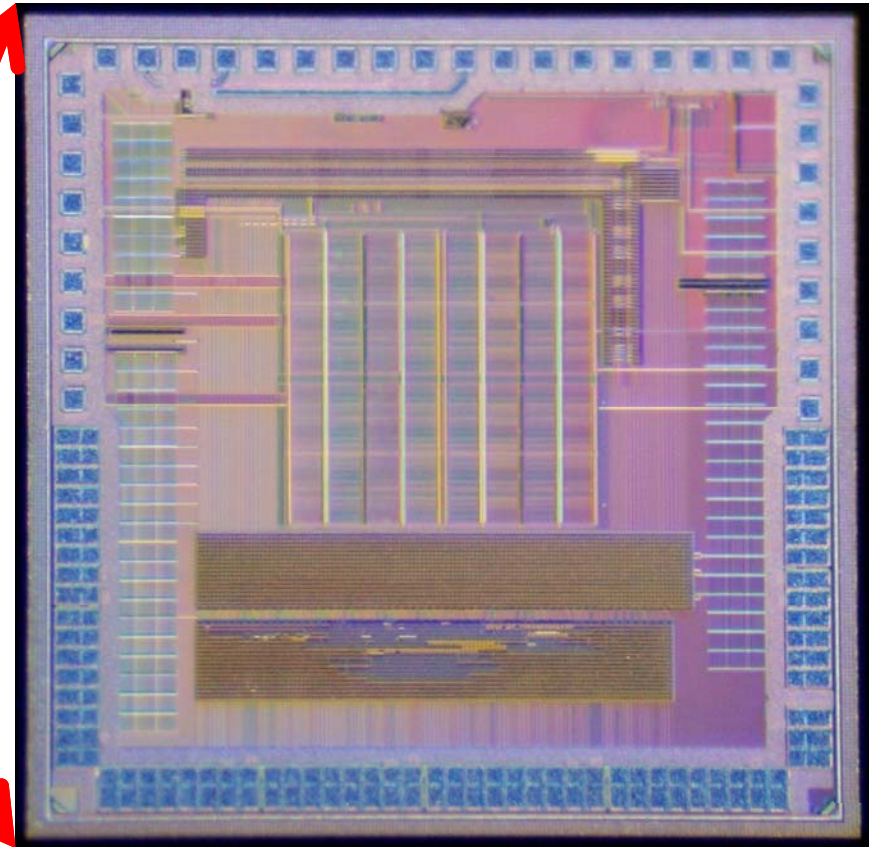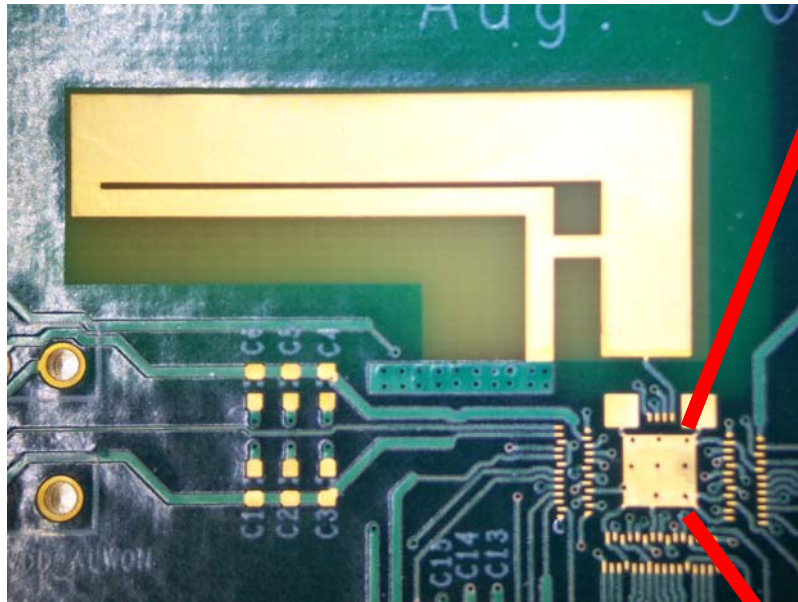
Chip Layout and Floorplan

Chip size: 2mm x 2mm

Utilizes full-custom layout and design for the radios and power, generated standard cells for digital.

Sent to Fab: May 2010
Return from Fab: Sept 2010

Hot off the Press: Chip Die Photo

2 mm

We have developed a ActiveRFID Platform

- Enables small active RFID nodes powered purely by energy scavenging with less 10 uW of average power

- Are easy to deploy and can use existing infrastructure

- Can communicate over more than 10 m indoors

- Fully integrated design contains all power management and communication circuits

- Testing underway

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