Advanced Packaging for Wearables (Vital Signs Monitoring)

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IMAPS New England
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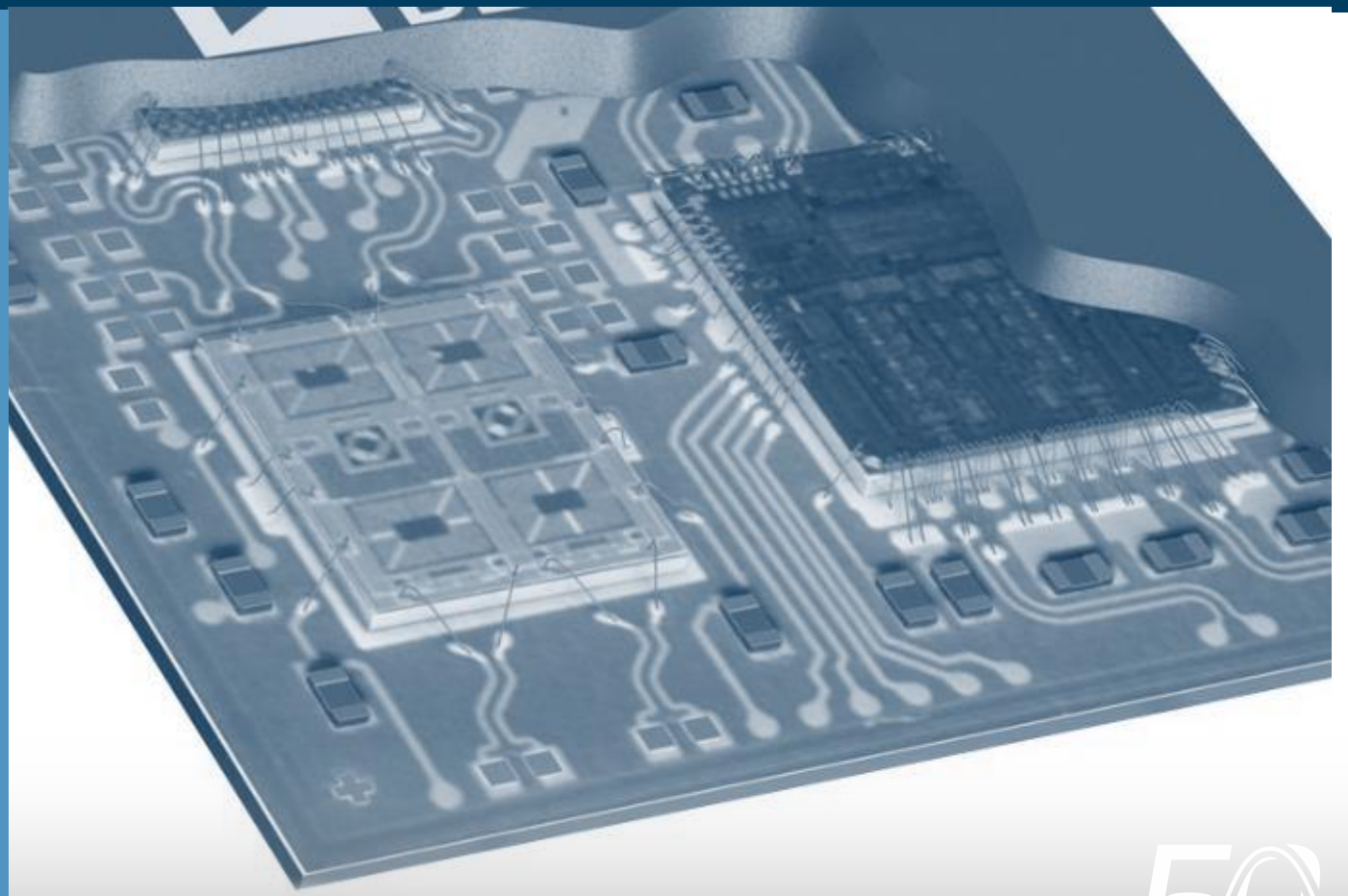
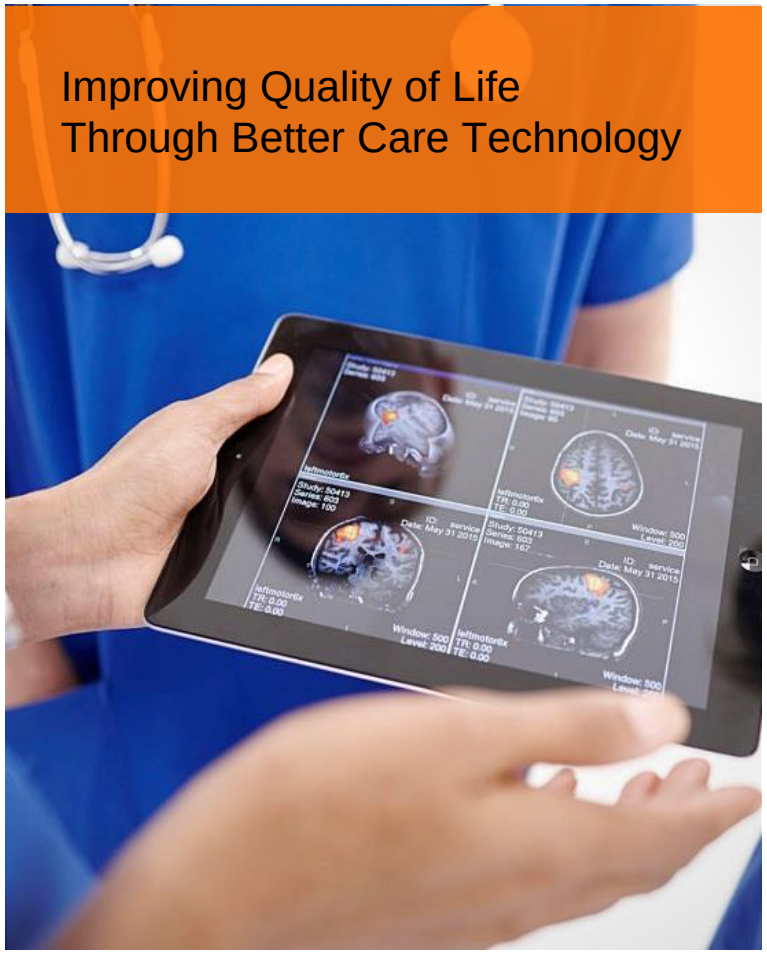


Healthcare at ADI



Diagnostics & therapy

- Imaging subsystems for ultrasound, digital X-ray, and CT detectors
- Miniaturized sensing for point of care diagnostics and minimally invasive procedures (catheters, surgical robots, and implantables)

Diagnostic Imaging Subsystem

Wellness & disease management

- Mobile solutions for digital health
- Long battery life
- Clinical grade performance

Vital Signs Monitoring/Wellness Platform

Prevention and Wellness → Diagnosis → Treatment and Therapy → Disease Management

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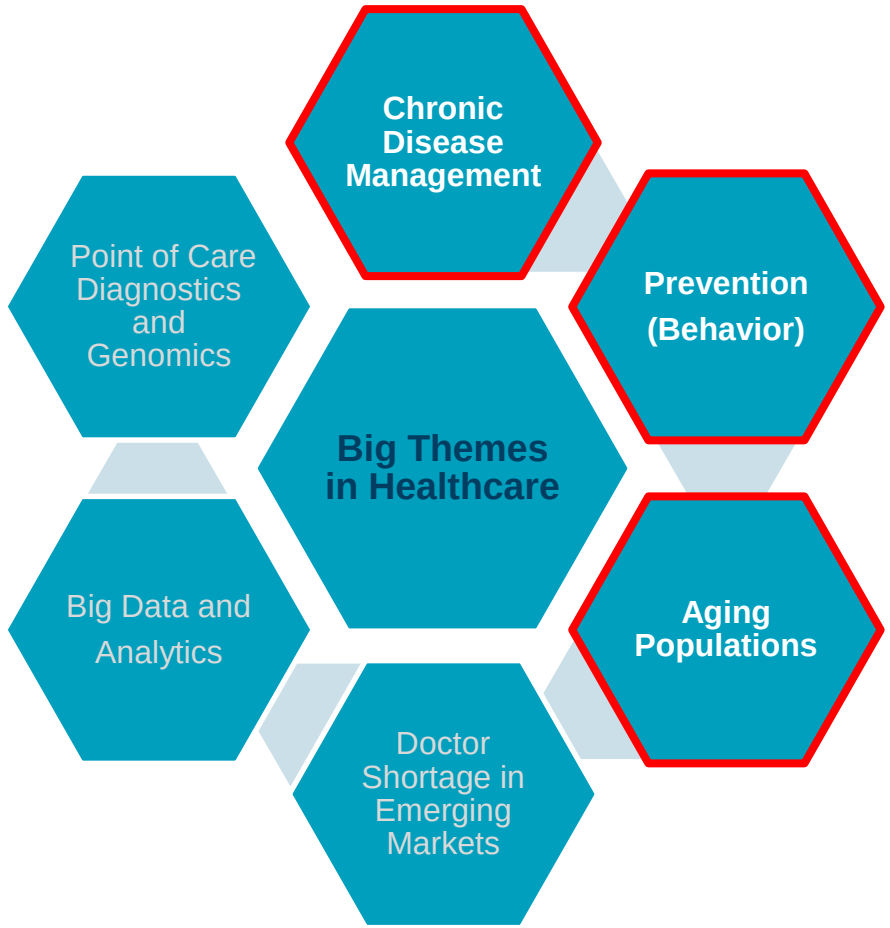
Wearables for Remote Monitoring Outside the Hospital

- Chronic Disease Management
  - Medication adherence and titration
  - State of wellness or decline, trends
  - Remote patient management and telemedicine
- Prevention
  - Lifestyle Habits: Behavior Change
  - Stress, Sleep, Nutrition, Activity
- Aging in Place
  - Emergency Detection (ex: Falls)
  - Lifestyle Analytics (activity, mental state, motor skills)



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Body Worn Sensing

Head

Wearables (headphones), gas sensing

Core Body

Breathing, core temp, stress markers, heart rate, EEG

Wrist

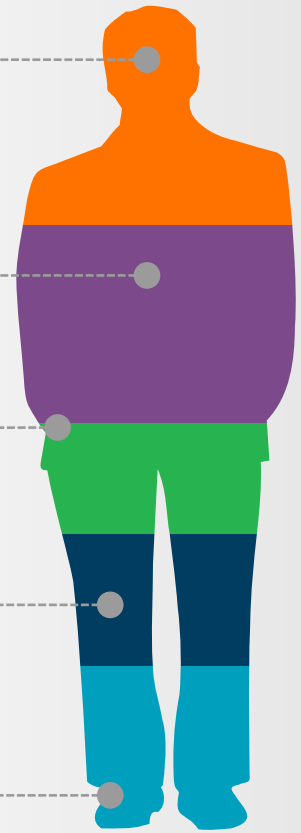
Heart rate, EEG, exercise monitoring

Extremity

Muscle firing, limb motion, stress markers

Shoe Sensing

Location based services, gait / movement analysis



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How Electronics Can Make a Difference

Small
Clinical Accuracy
Long Battery Life

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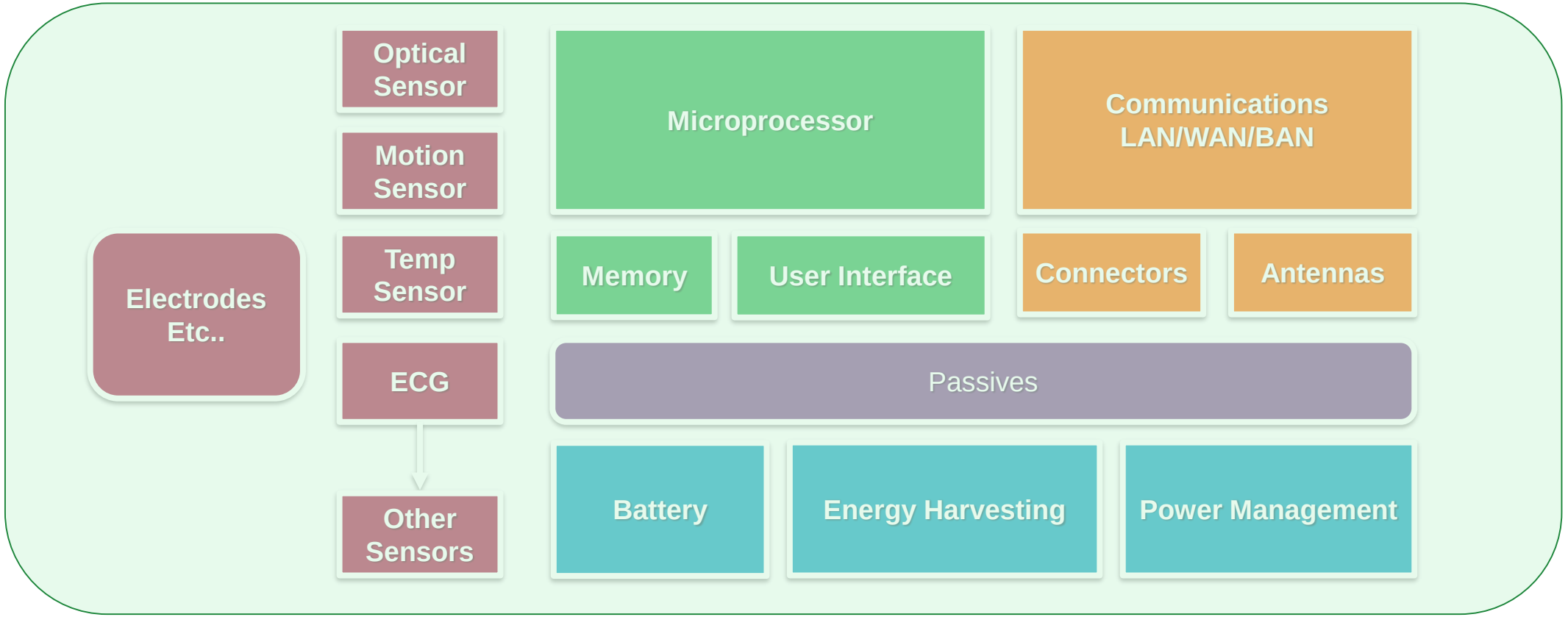
A Typical System Level Solution



Co-Packaged!

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Vital Signs Monitoring Flex Package Examples at ADI

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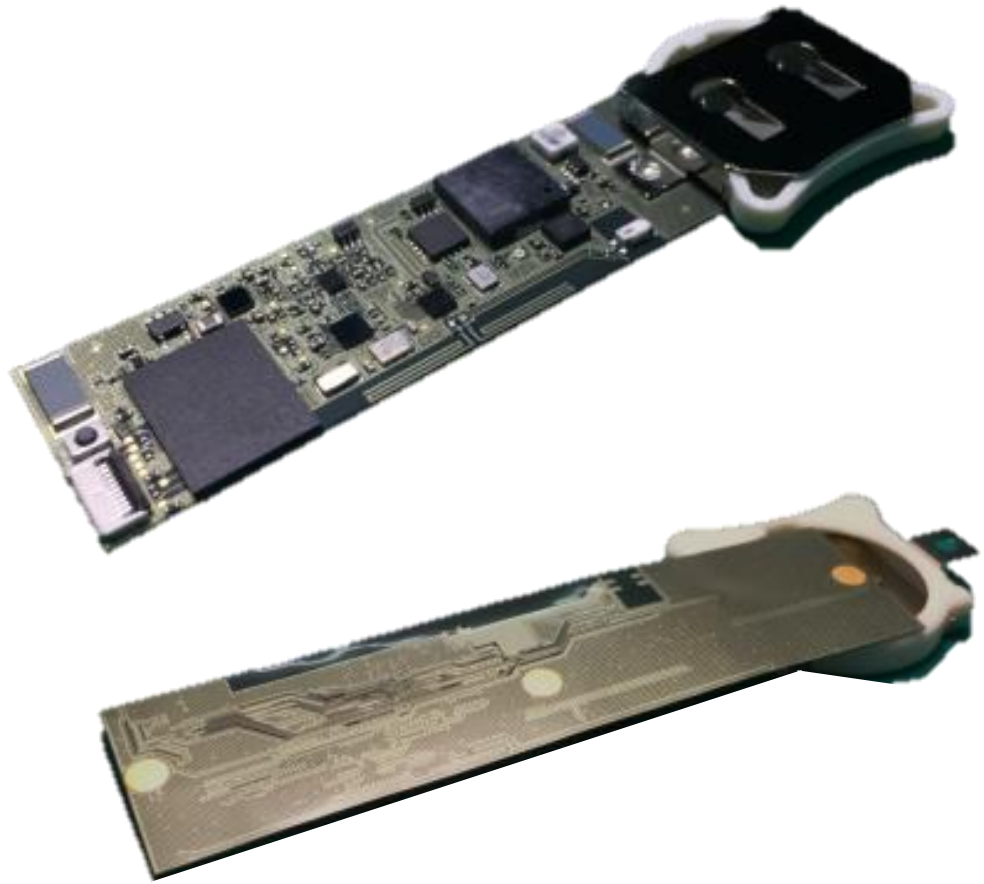
Disposable Vital Signs Monitoring Patch

- Supports short/medium term wear on the skin
- Technology
  - Dual sided, plated flex (60um pitch min.)
  - ECG electrodes + AFE
  - Skin temperature sensing
  - Micro-processor
  - RF communication w/patterned or discrete antenna
  - Power management based on coin cell or flat battery
  - Buttons for user interface
- Challenges
  - Low cost flex technology
    - Printed at equivalent geometries in 2 layers (vias)
    - Solder mask or equivalent
    - High temperature capable for assembly (solder or equivalent)
  - Robust, bio-compatible materials and processes for adhesion to the skin



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Rechargeable Vital Signs Monitoring Patch

- Supports longer term wear or integration in textiles
- Technology
  - Dual sided, plated flex (60um pitch min.)
  - ECG electrodes + AFE
  - Micro-processor
  - RF communication w/patterned or discrete antenna
  - Power management w/inductive, wireless charging
  - Buttons for user interface
- Challenges
  - Low cost flex technology
    - Printed at equivalent geometries in 2 layers (vias)
    - Solder mask or equivalent
    - High temperature capable for assembly (solder or equivalent)
  - Robust materials and processes for textile integration

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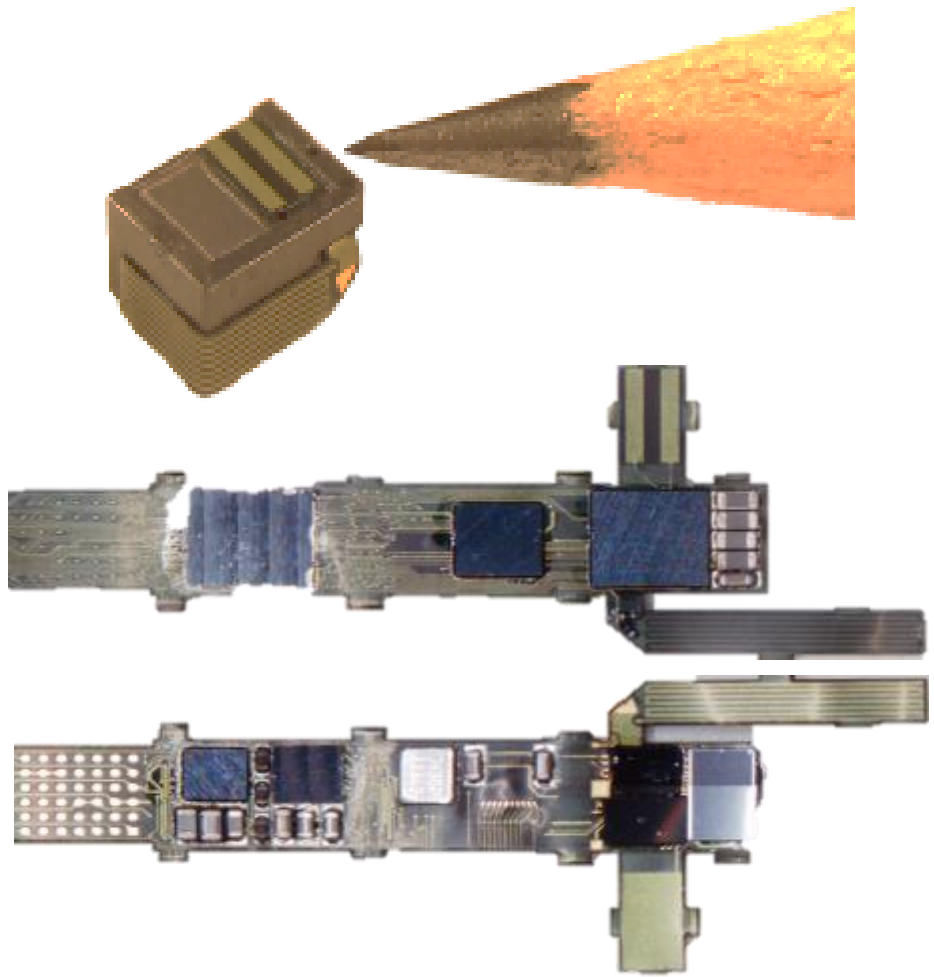
High Density Integration and Miniaturization

- Supports sensor integration in extreme, space-constrained applications (hearing aids, jewelry, pills, etc.)
  - PPG / SP02 (optical)
  - ECG w/filtering on IPD
  - Activity (XL-based)
  - Cap Touch w/electrodes
  - 3D Gesture
  - BTLE w/antenna and matching circuit on IPD
  - Antenna
  - Microprocessor
- Technology
  - Dual sided plated flex (30um pitch min.)
  - Silicon IPDs
  - Flip chip, wirebond, passive reflow
  - Flat or folded (4.0 x 5.0 x 2.5mm)
- Challenges
  - Performance of sensors and electronics in tight spaces
  - Battery technologies



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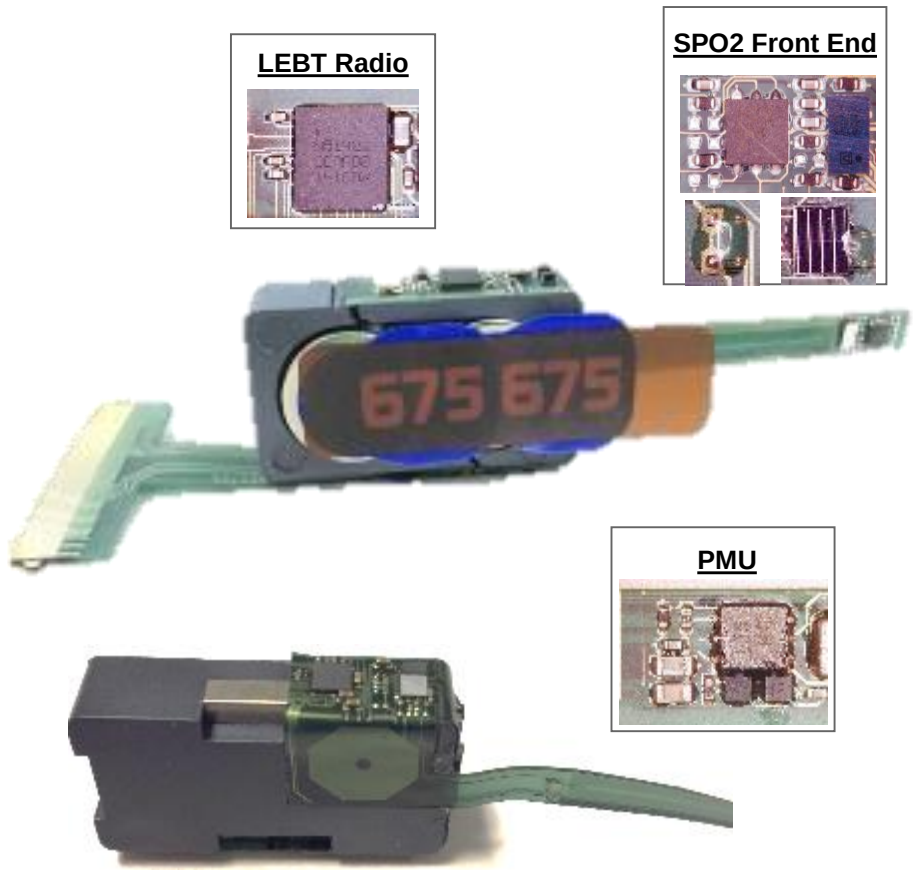
Optical Sensing for SPO2 at the Finger

- Supports integration into patches and clips bending around the finger
- Technology
  - Dual sided plated flex (40um pitch min.)
  - Optical AFE + PDA + LED
  - Accelerometer
  - Micro-processor
  - LEBT + matching circuit + patterned antenna
  - NFC + coil
  - Power management and two zinc air batteries
  - Passive components
- Challenges
  - Robust materials and processes for patch integration
  - Battery technology



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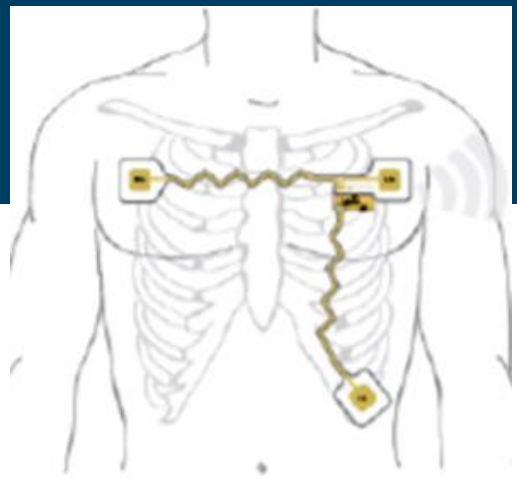
Flex Density vs. Cost

- The challenge
  - Plated flex = capable of density, but costly
  - Low cost printed flex and assembly = not mature
- Requirements
  - 2 routing layers (vias)
  - 30um line and space
  - Solder mask (or equivalent) at 30um registration
  - Support temperatures required at assembly
    - High temperature solder, or
    - Low cost, lower temperature epoxy



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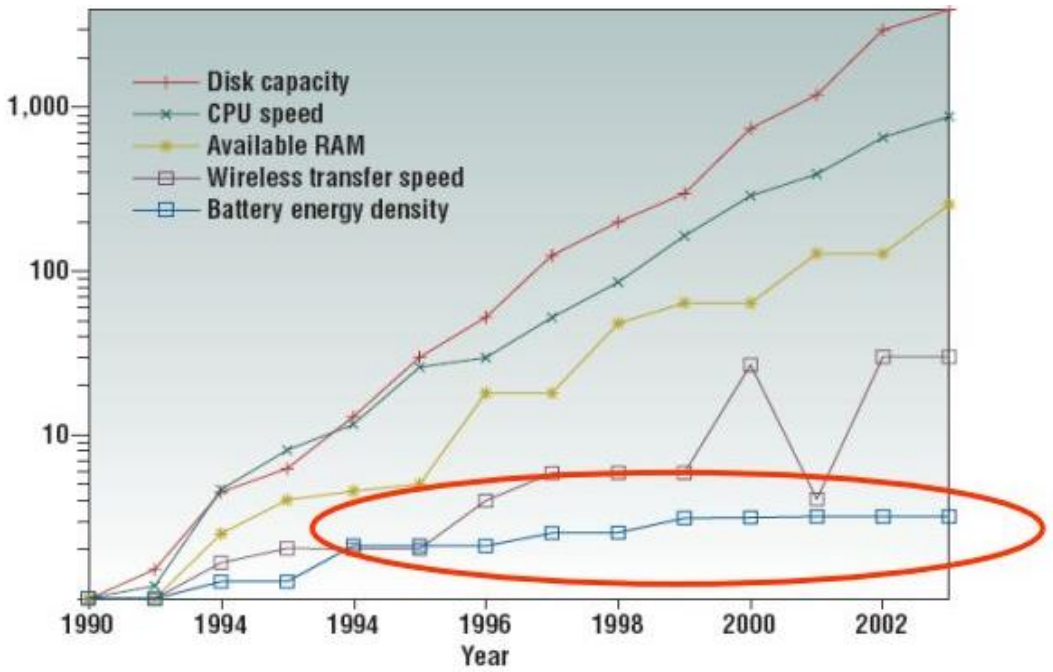
Extending Battery Life

- Batteries don't follow Moore's Law
- Strategies for longer battery life
  - Improve efficiency of electronics (100X in last few years)
  - Clever algorithms
    - Where and how often to measure
    - Curate data quality
  - Manage the power hogs
    - Radio is 20mW vs. processor and sensor/AFE at 1mW each
    - Processing at the node is more efficient that transmitting to the Cloud
  - Energy harvesting



Mobile Computing Improvement – Paradiso, *et al.* Pervasive Computing, IEEE, 2005.

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Advanced Packaging for Wearables

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Conclusions and Needs

- Ultra low power electronics and sensors
- Novel radio schemes
- Higher density and flexible batteries
- Low cost flexible substrates and interconnects
- Bio-compatible, robust and reliable integration into textiles

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