Ultra Low Power Electronics for Undetectable ASTs

Ben Calhoun

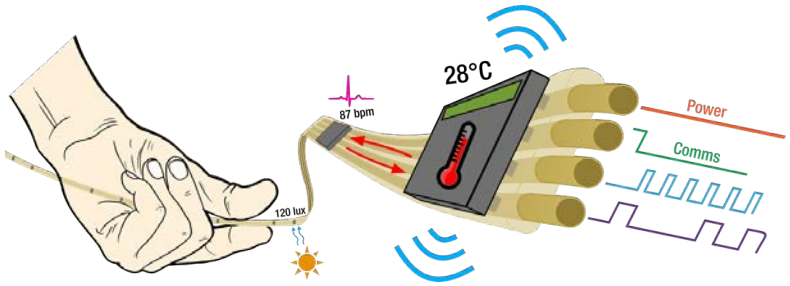
University of Virginia

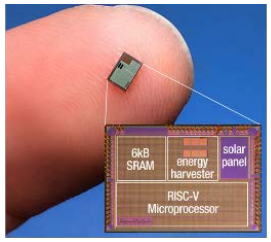
May 2022

bcalhoun@virginia.edu

Advanced Smart Textiles (ASTs) are Power-Limited

- Any AST using conventional chips will need a "puck" to house batteries and electronics somewhere in the system
- Get the puck out! → lower power to microwatt range
- To integrate in textiles or fiber, we need a distributed network of components with integrated power & data

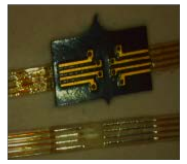


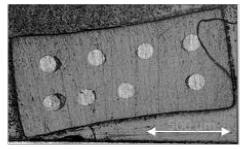


Segment SoC (System on Chip)

- **1.5 nW to 10 nW**
- MCU, SRAM, bus, DC-DC, harvesting, temp sensor

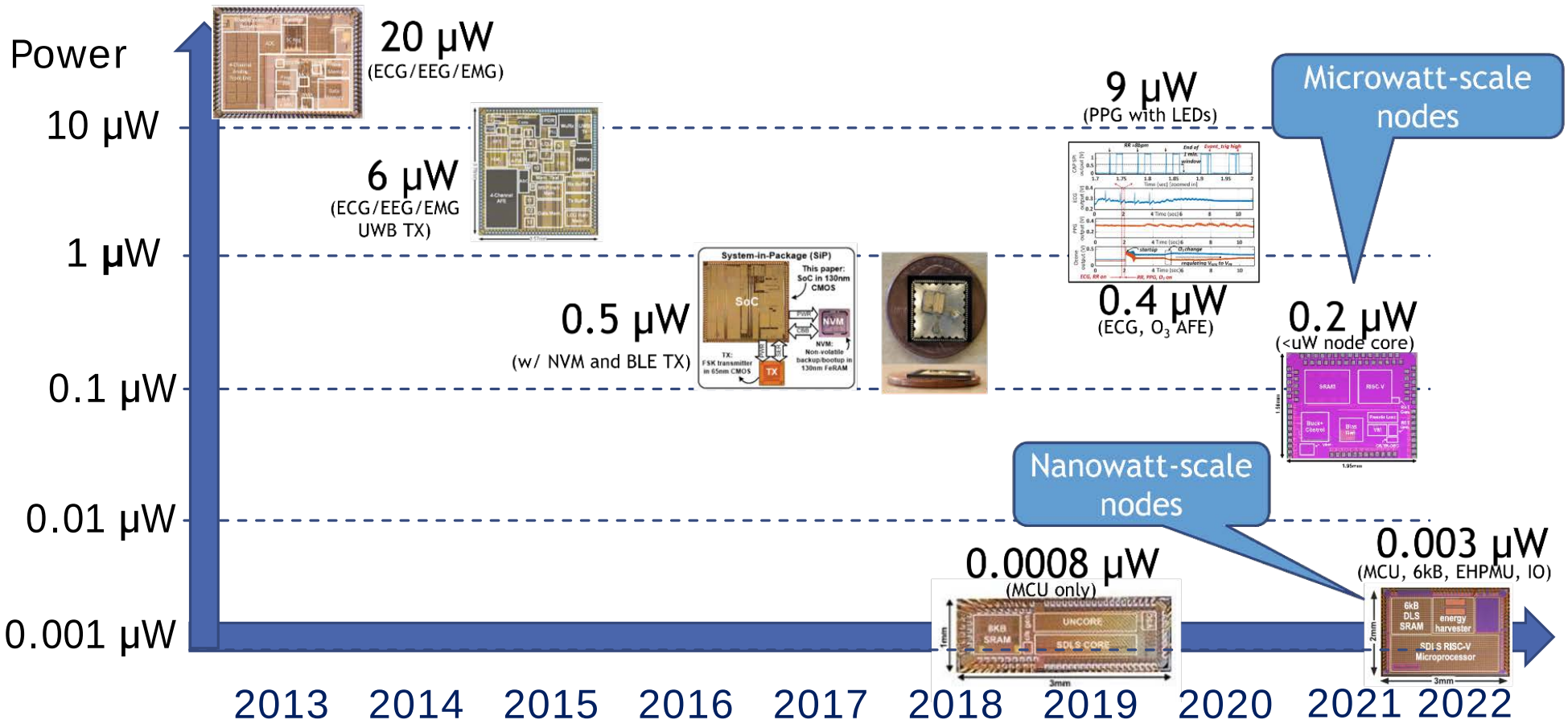
On interposer





Fiber Development (MIT-LL)

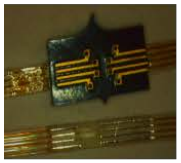
UVA Systems-on-Chip: Do a lot for **µWs!**

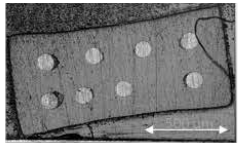


Integration with Fiber and Fabrics

- Components placed around garment
  → Multiple techniques
- Collaborations to show variety of integrated components and technology options

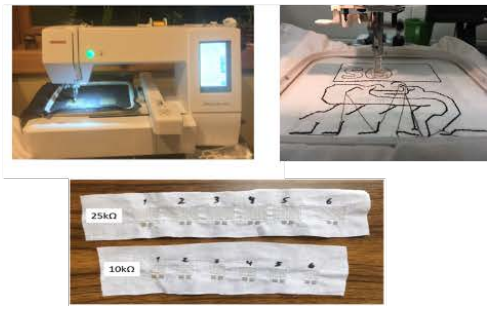
Into Fiber: integrated bus and power
(MIT-LL)





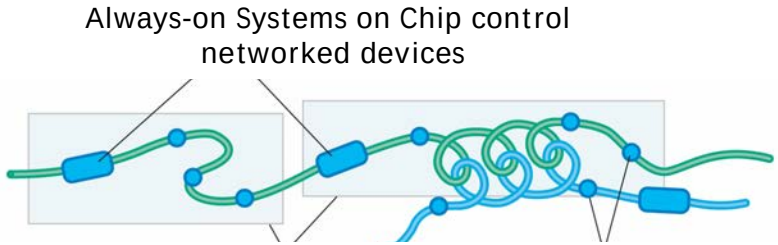
Into textiles: sensors, energy harvesting, interconnect, antennas, energy storage
(ASSIST Center, NCSU)

Embroidered components: sensors, energy harvesting, textile actuators
(Sarah Sun, UVA)

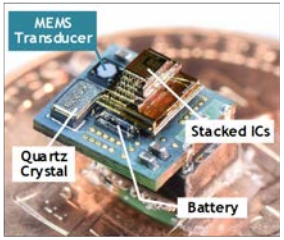


System integration

- Distributed network of components with integrated power & data
- Components support IARPA use case at microwatts or below

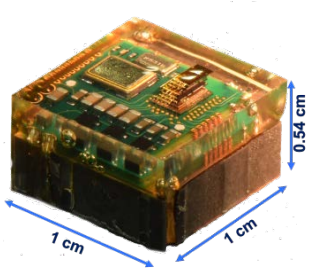


Sensing: Audio sensing, imaging w/ detection
(Dennis Sylvester, UMich)



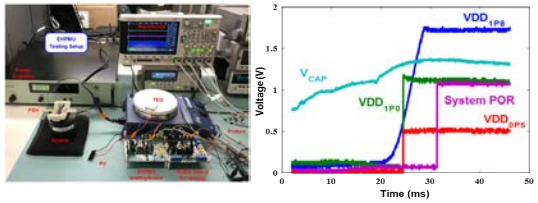
- 142nW Voice Activation
- Analog front end, mic
- Neural net classifier
- mm-scale imaging

Sensing: GPS
(Dave Wentzloff, UMich)



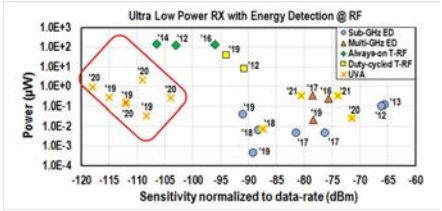
- GPS AFE: 13µW to 10mW
- 100ms RF recording time
- 32 satellite search
- 28 days of fixes stored
- Battery or PV powered

Power: DC-DC conversion, energy storage, energy harvesting
(UVA)



- ~90% efficient at nW to µW
- Multiple in, multiple out
- Store: battery or supercap
- Harvest: light, temp, motion

Data, memory, processing, communications
(UVA)



- Lowest power SRAM: <nW
- Non-volatile memory: **µW**
- Digital acceleration and processing
- Wakeup RX: -110dBm at <100nW