NACK NETWORK Building College-University Partnerships for Nanotechnology Workforce Development

NCI Southwest

Self-Powered Wearable Devices for Monitoring Personal Health
Monday, June 13, 2016

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Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)

Begin Recording

Veena Misra, Center Director and Professor, ECE
North Carolina State University

Poll

The terms “**wearable** technology“, “**wearable devices**“, and “**wearables**” all refer to electronic technologies or computers that are incorporated into items of clothing and accessories which can comfortably be worn on the body.

Do you currently own a wearable device:

Yes
No

Poll

If you have a wearable device what do you primarily use it for?

A. Fitness
B. Health
C. Fashion (Cool Factor)
D. Communication
E. Navigation/Location
F. Other (use question box to reply)

Poll

If you have a wearable device how long have you been using it?

A. 3 months or less
B. More than 3 months but less than a year
C. One year or more
D. I want to get a wearable device

The Wearable Space and State

Wearables have **high power consumption**, **limited functionality**, **data inaccuracies** → Can this address health needs**?**


Healthcare Costs → 17% U.S. GDP
75% : Chronic Disease
1 in 3 Americans: Multiple Chronic Diseases
Doctor Visits: 4 times a year
1 in 4 Americans : Poor air quality

ASSIST's vision is to use nanotechnology to impact healthcare and manage wellness

By building self-powered wearable, wireless, multiple sensor platforms that enable:

- Long-term monitoring of personal health & environment
- Correlation of multiple sensors
- Increased compliance through hassle-free usage

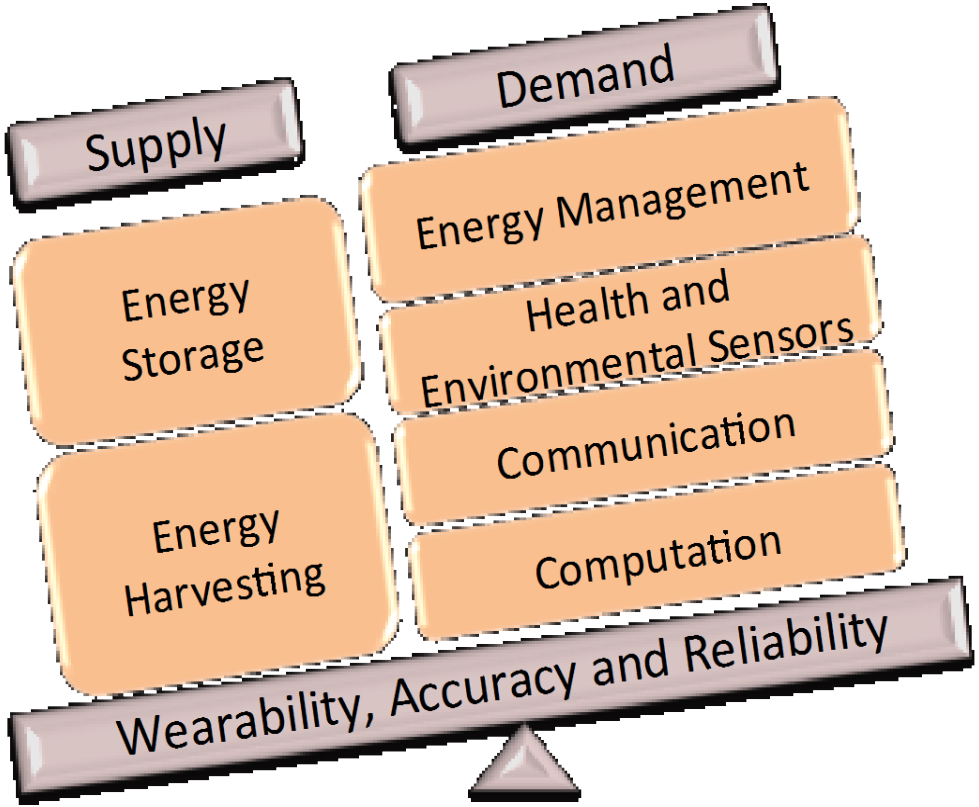
Power Generation > Power Consumption

Harvested and Stored Power

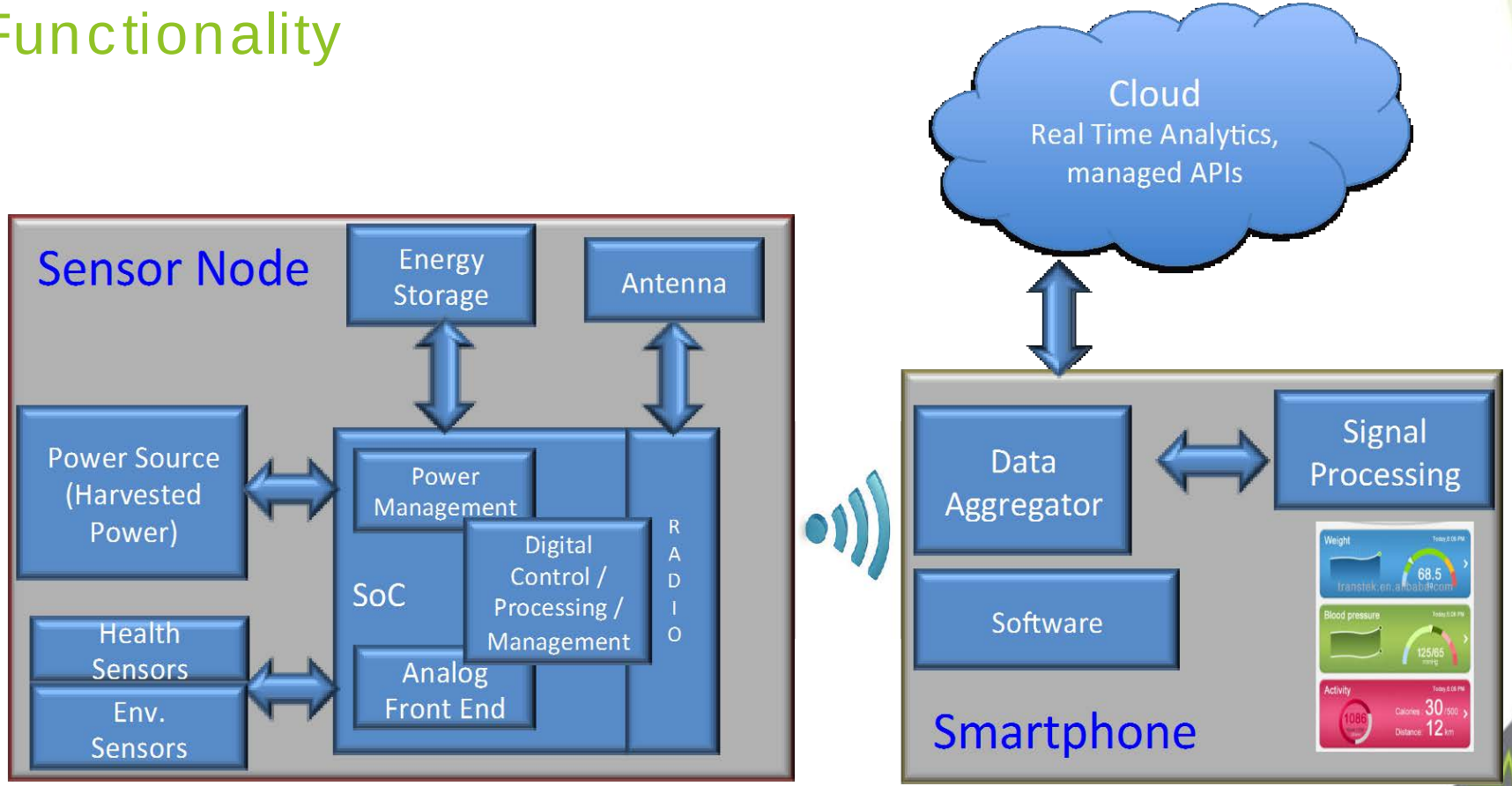
Low Power Electronics and Sensors

Wearability and Data

Self-Powered/Low-Power Sensor Platforms: ASSIST is uniquely innovating both sides of the power problem

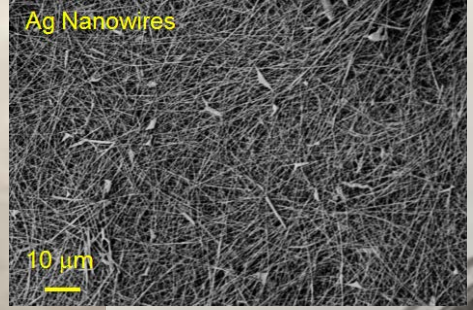


Critical Components to Achieve Testbed Functionality



Power Generation > Power Consumption

Power Generation > Power Consumption



ASSIST Team, Proceedings of the IEEE, April 2015

SSIST

Energy Harvesting & Body Map Integration

Amanda Myers, Ryan Hodges, Jesse S. Jur, NCSU

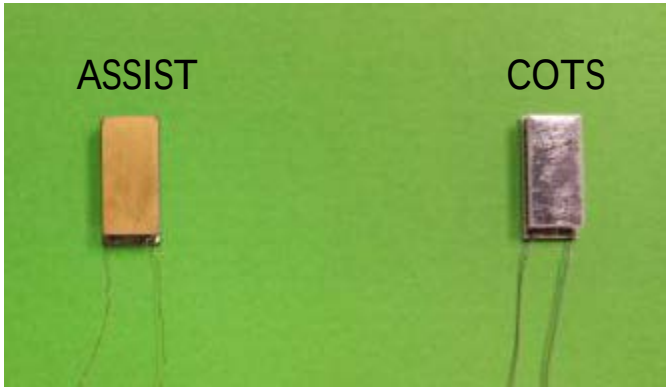
Objectives

Accomplishments

Flexible Heat Sink Design

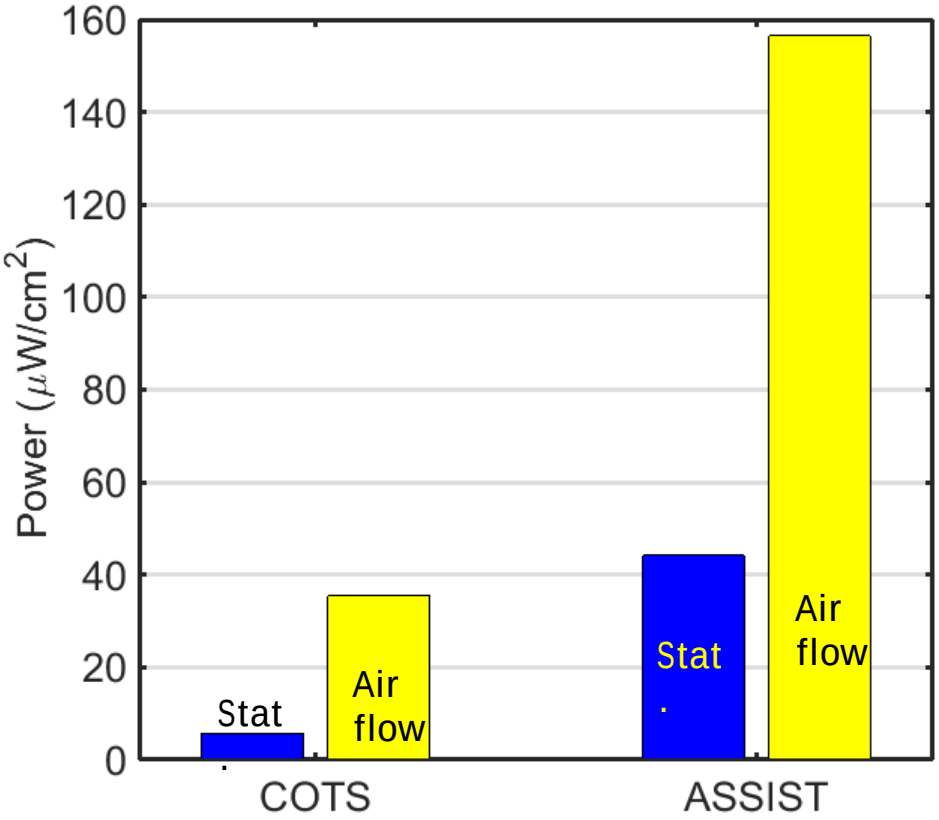
Wearable Energy Harvesting

Comparison with Commercial TE Devices



	V_{oc} (mV/cm^2)	I_{sc} (mA/cm^2)	P_{out} (μW/cm^2)	
COTS	18.4	1.5	5.7	Stationary
COTS	52.9	3.2	35.5	Airflow
ASSIST	49.7	3.9	44.2	Stationary
ASSIST	97.4	7.1	156.5	Air flow

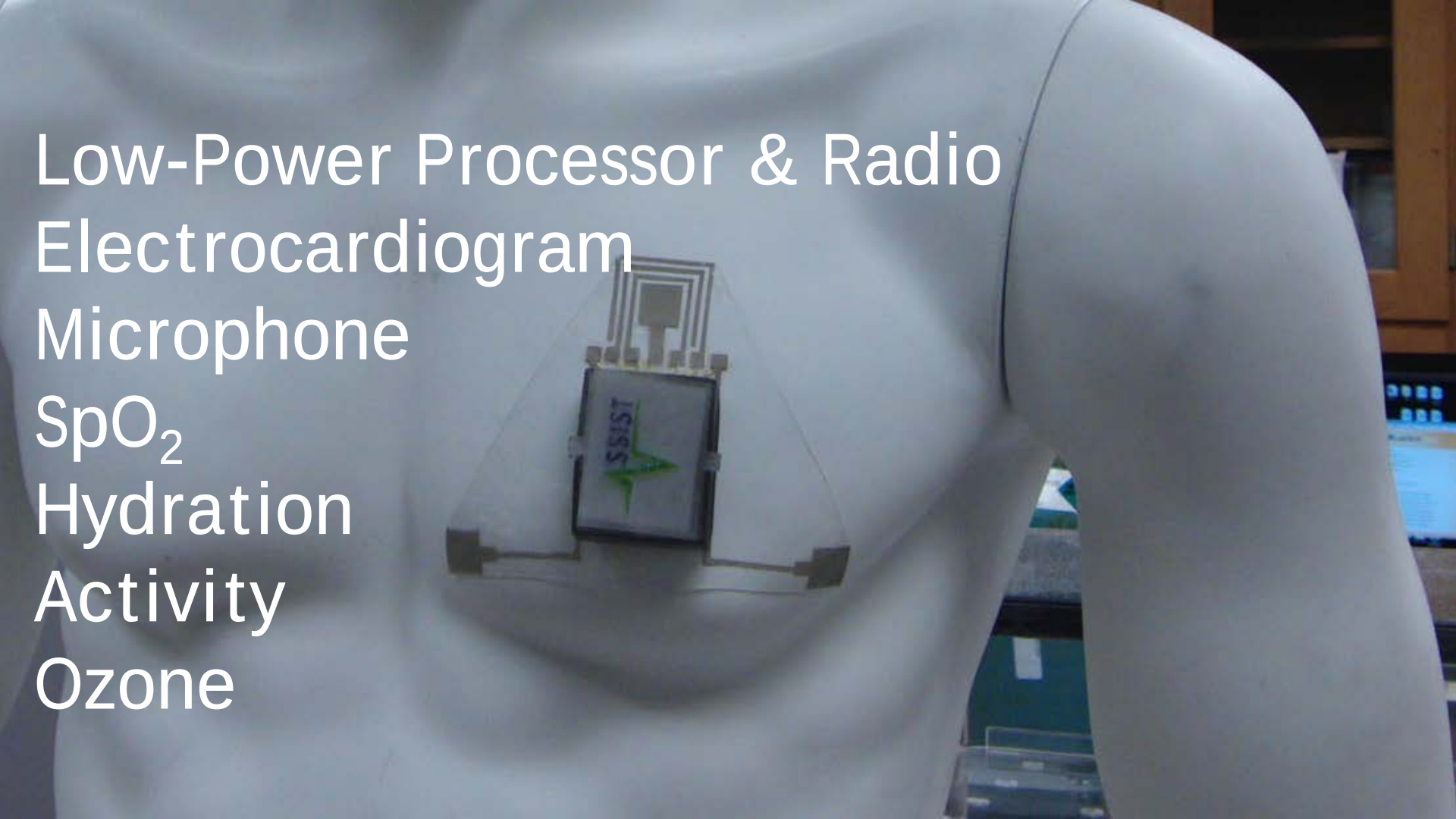
Used 14.3 cm^2 spreader on both sides.



Vashaee

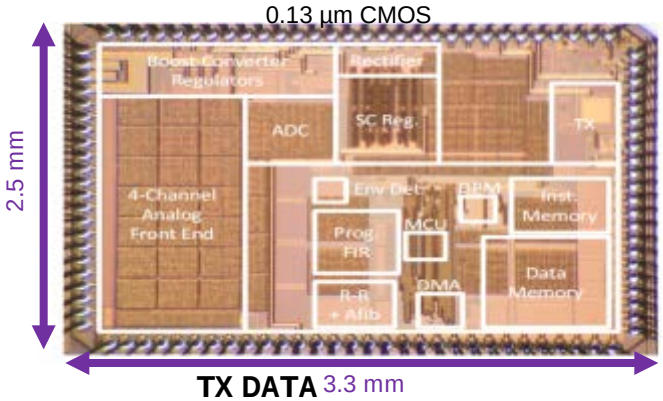
Questions from audience on energy harvesting?

Power Generation > Power Consumption



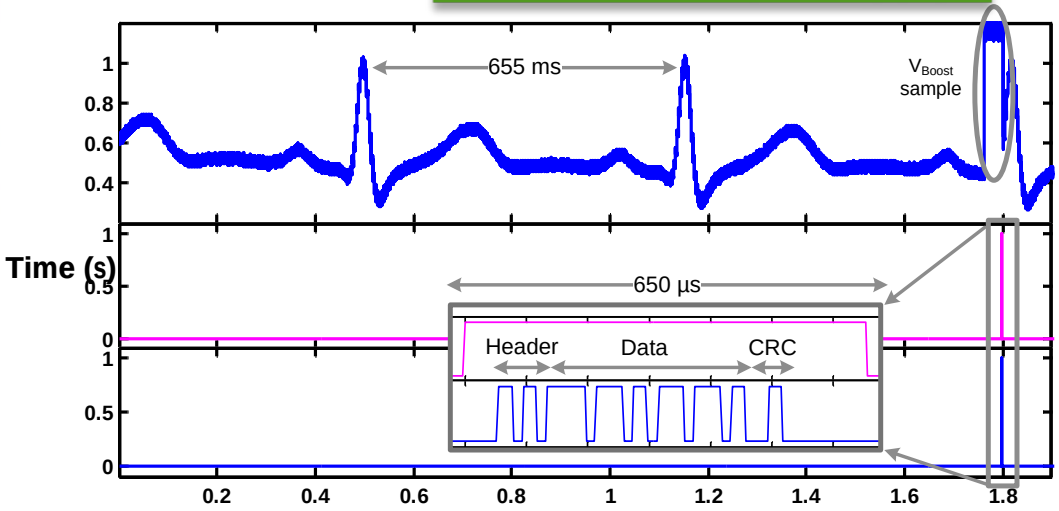
Low-Power Processor & Radio
Electrocardiogram
Microphone
SpO_2
Hydration
Activity
Ozone

Ultra Low Power System on Chip



Calhoun et al., ISSCC 2012

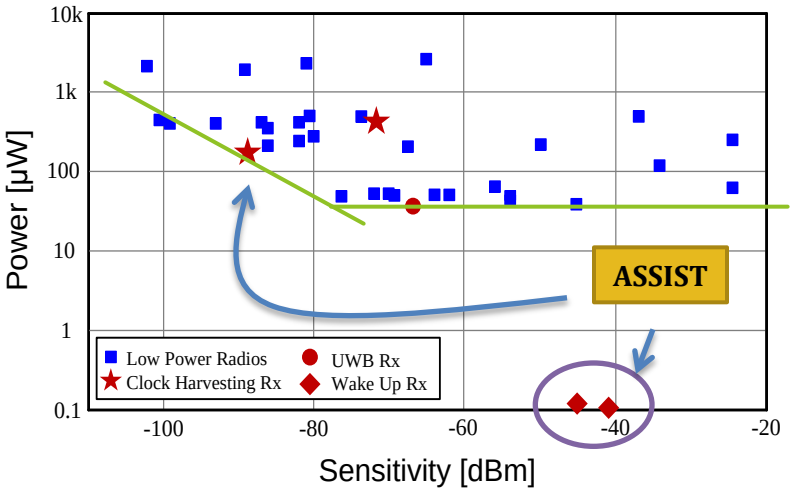
19µW total chip power from 30 mV input supply



Calhoun / Wentzloff

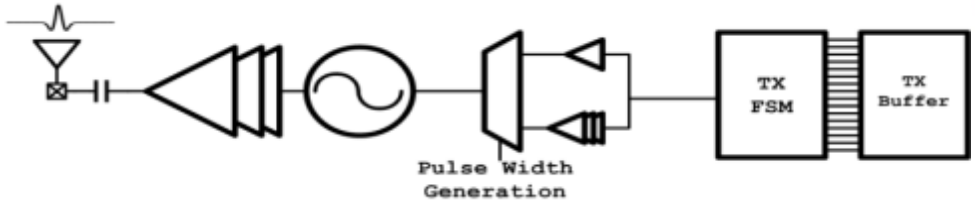
Battery-Free ECG < 20µW relying only on energy harvesting and storage capacitors.

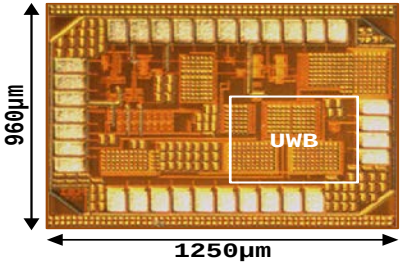
ASSIST Ultra-Low Power Radios



Ultra wideband (UWB) Transmit

ULP TX for system level energy savings





Spec	Value	Unit
Power	**7.44**	**µW**
Data Rate	**187.5**	**kbps**
Center Frequency	3.8	GHz
Bandwidth	490	MHz
Output power	---	dBm

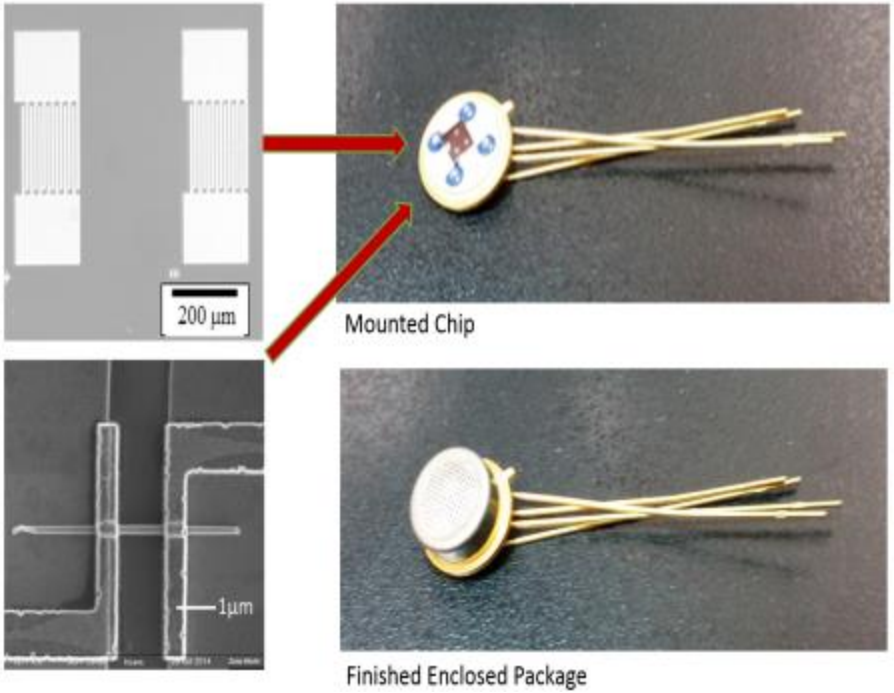
Wentzloff/Calhoun

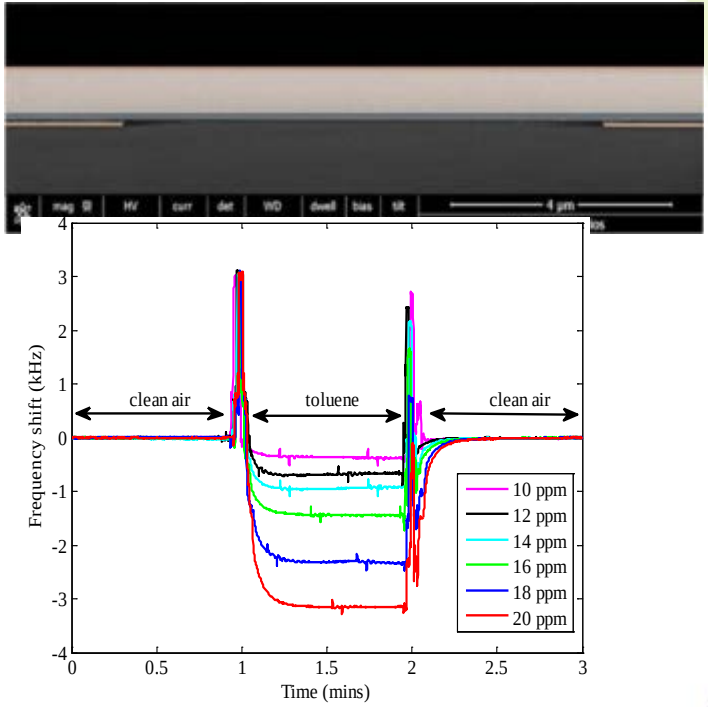
MICHIGAN

UNIVERSITY of VIRGINIA
SCHOOL OF ENGINEERING

Low Power Gas Sensors

77 µW when operated with 10% duty cycle from a 1.5-V supply



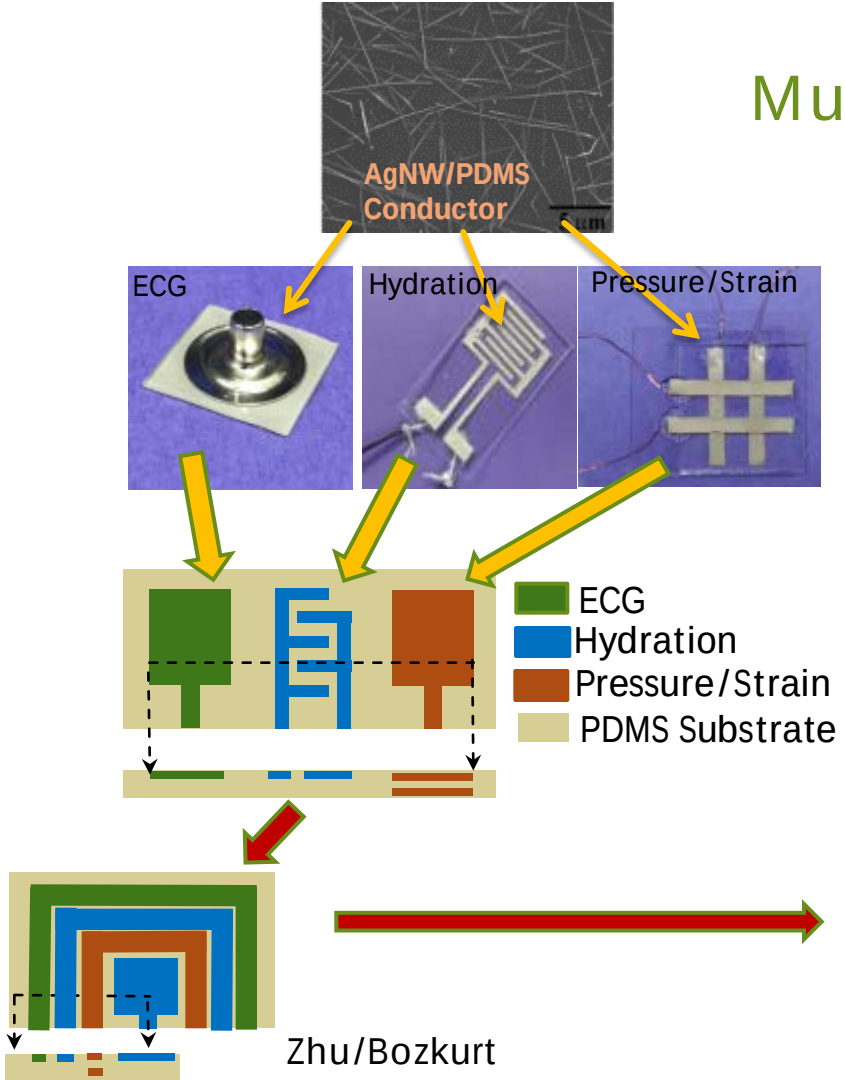


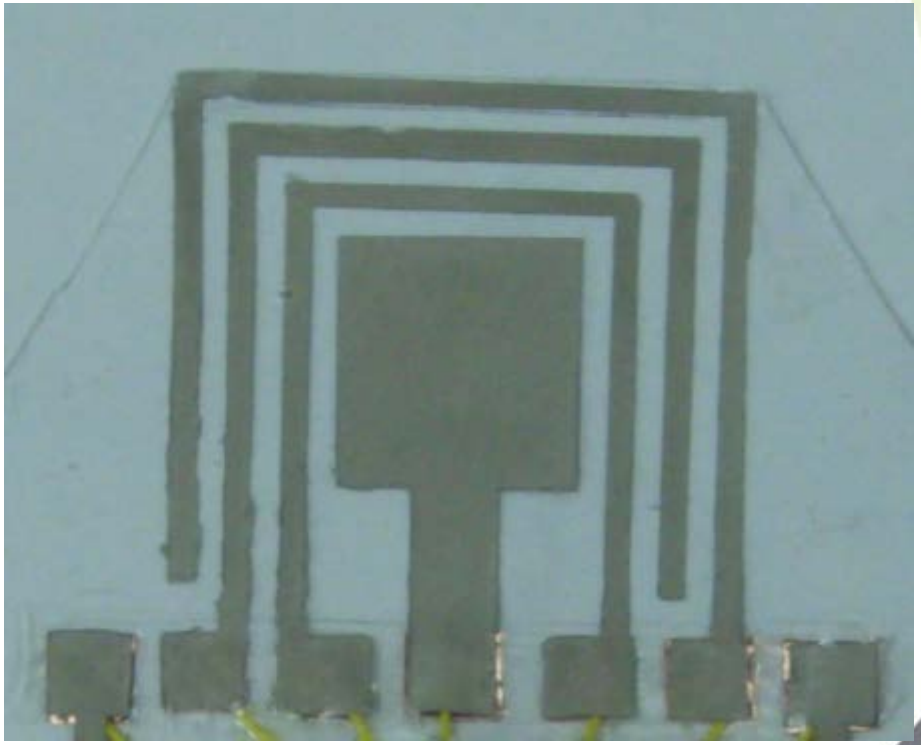
- Ozone sensing power consumption **<50 nW**
- Sensor **reset by UV** exposure
- Projected **power ~ 100 µW** with 2% UV duty cycle

CMUT resonators for VOC sensing

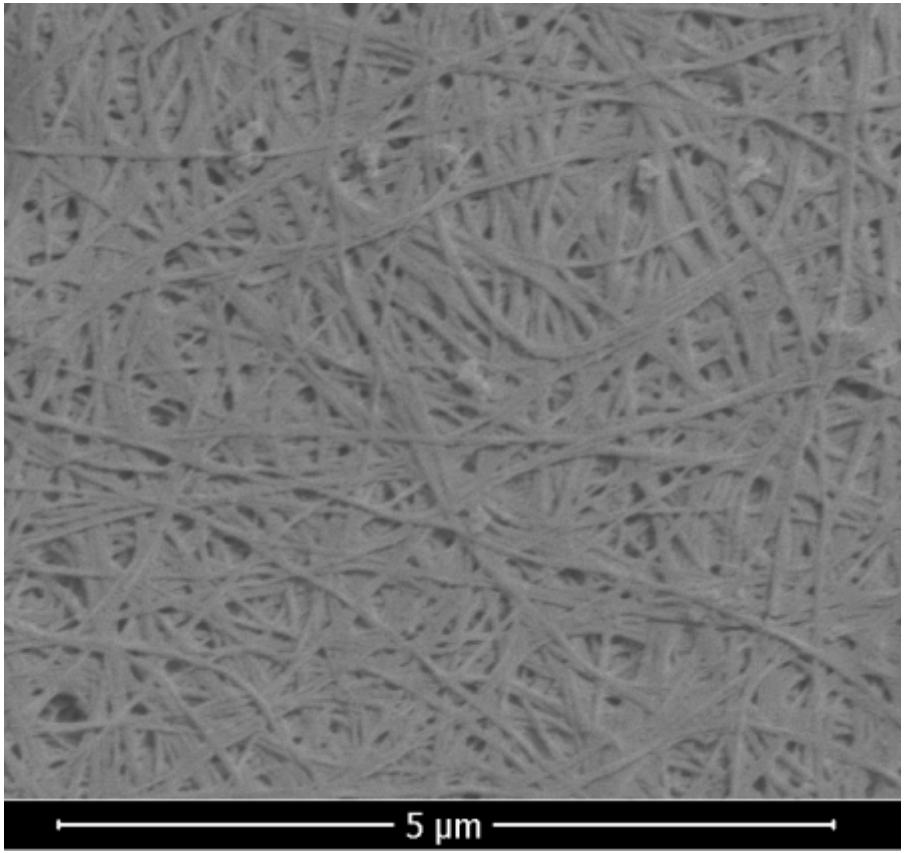
Misra/Oralkan

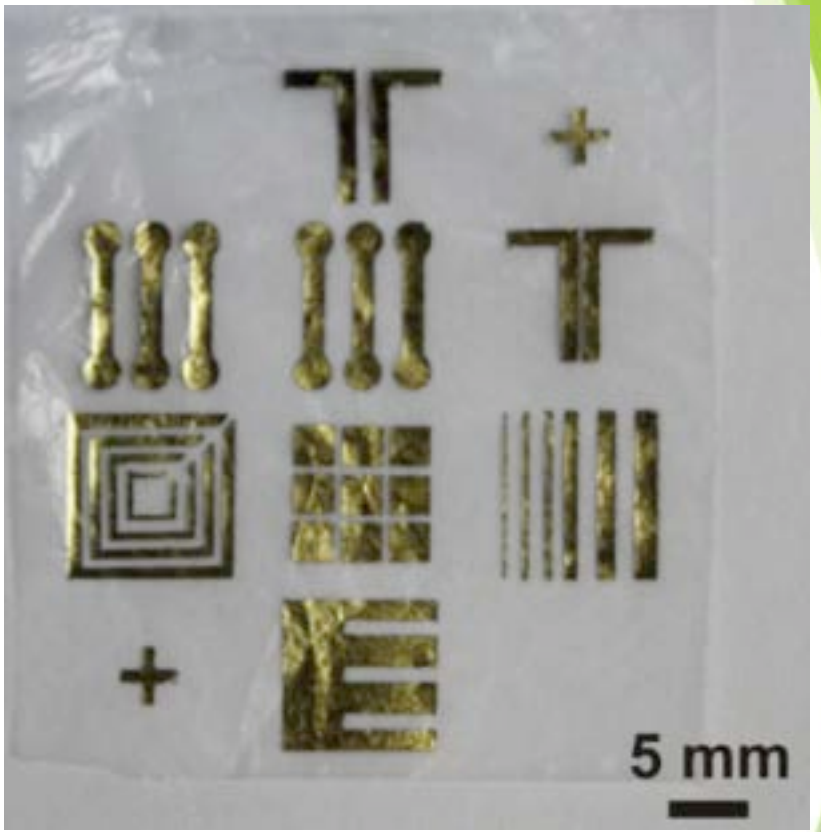
Multimodal Electrodes





Zhu/Bozkurt

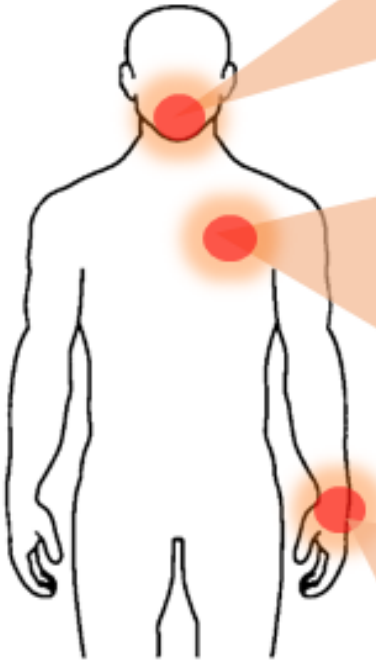




Breathable patches for sweat glucose

Questions from audience on low power electronics and sensors?

Integrating Technologies into Systems for Chronic Disease Management



Spirometer

- Flow Sensor
- Accelerometer
- System on Chip

BLE

Chest Patch

- Microphone
- Strain sensor
- Skin impedance
- ECG
- Accelerometer
- Pulse Ox
- System on Chip

BLE

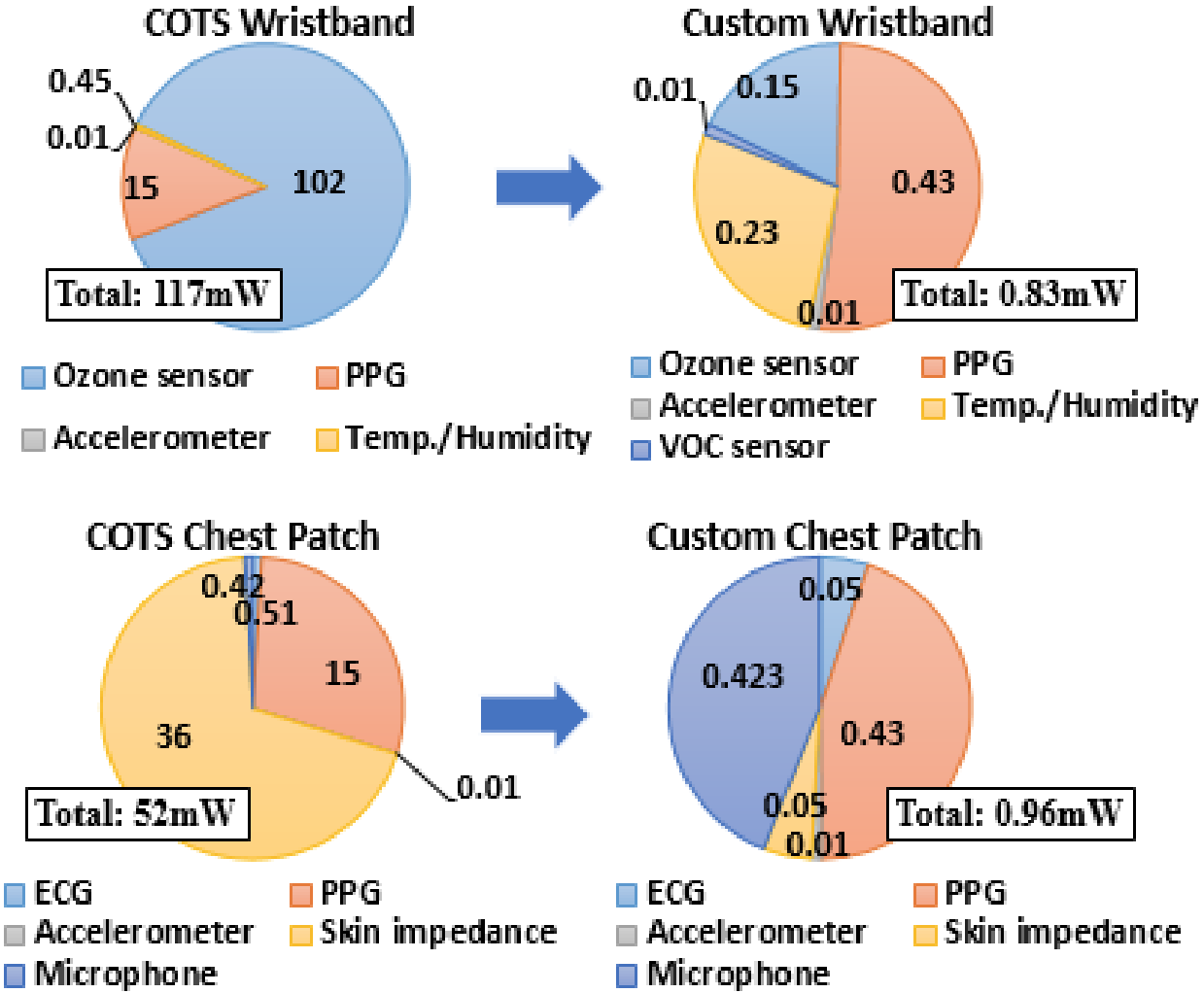
Wrist Band

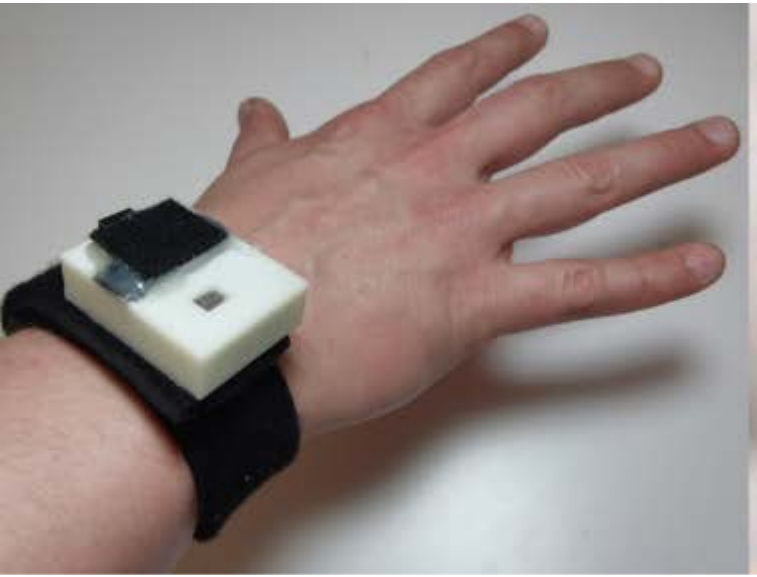
- VOC sensor
- Accelerometer
- Ozone sensor
- Pulse Ox
- Humidity/Temp sensor
- System on Chip

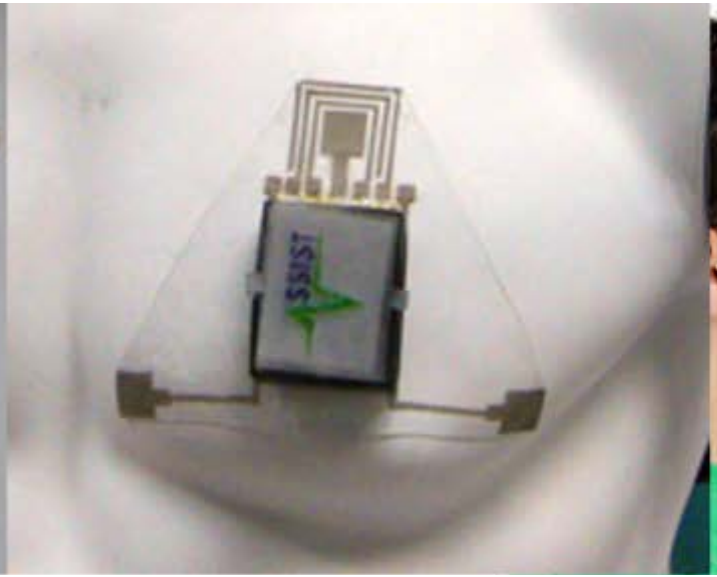
BLE

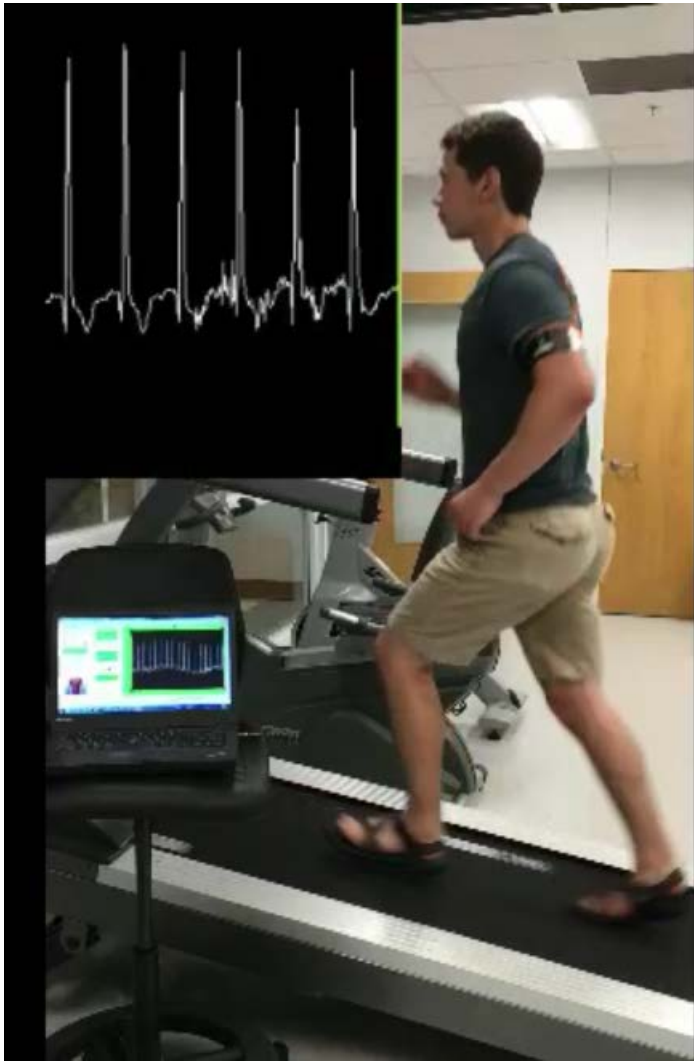
Acquisition Software

- Connection
- Calibration
- Visualization
- Recording
- Upload to the Cloud


COTS Wristband
0.45
0.01
15
102
Total: 117mW
Ozone sensor
PPG
Accelerometer
Temp./Humidity
Custom Wristband
0.01
0.15
0.43
0.23
0.01
Total: 0.83mW
Ozone sensor
PPG
Accelerometer
Temp./Humidity
VOC sensor
COTS Chest Patch
0.42
0.51
15
36
0.01
Total: 52mW
ECG
PPG
Accelerometer
Skin impedance
Microphone
Custom Chest Patch
0.05
0.423
0.43
0.05
0.01
Total: 0.96mW
ECG
PPG
Accelerometer
Skin impedance
Microphone




SSIST



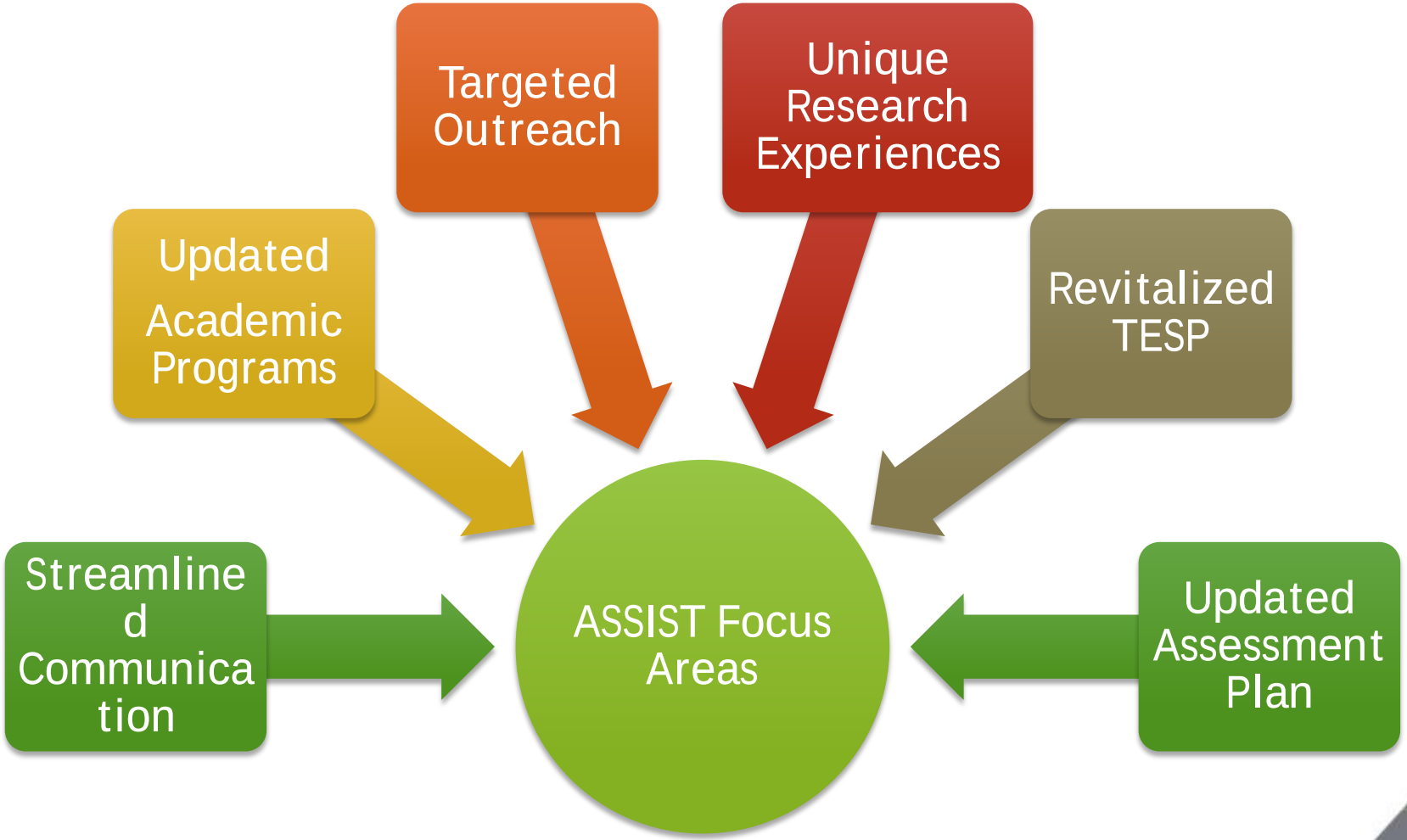
Questions from audience on ASSIST systems for disease management?

ASSIST's Educational and Outreach Mission

- Educational efforts span curriculum development, knowledge skills, undergraduate engagement and K-12 dissemination
- REUs, fellowships, senior design projects and nano-science and technology minor

Haywood Hunter transferred to NCSU from Wake Tech Community College.

ASSIST students represent the Center at IDTechEx and CES


Targeted Outreach
Unique Research Experiences
Updated Academic Programs
Revitalized TESP
Streamlined Communication
ASSIST Focus Areas
Updated Assessment Plan

Wearables are a powerful educational tool

- Senior design projects
- One Health Challenge
- Graduate Certificate
- ASSIST TED^{x} Raleigh

Membership (5 Full, 13 Associate, 11 Affiliate)

JSR Corporation

Wireless Research Center
OF NORTH CAROLINA

Impact of ASSIST's Self-Powered Wearable Health Technologies

- Manage **wellness** non-invasively and comfortably
- Establish **long-term health trends** for individuals
- **Predict onset** of life-threatening conditions
- Create **pipeline of future innovators** and leaders
- **Stimulate U.S. economy** with new technologies

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