

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



ASSIST Overview

EnerHarv
2024

Dr. Ravi Chilukuri
Innovation Ecosystem Director

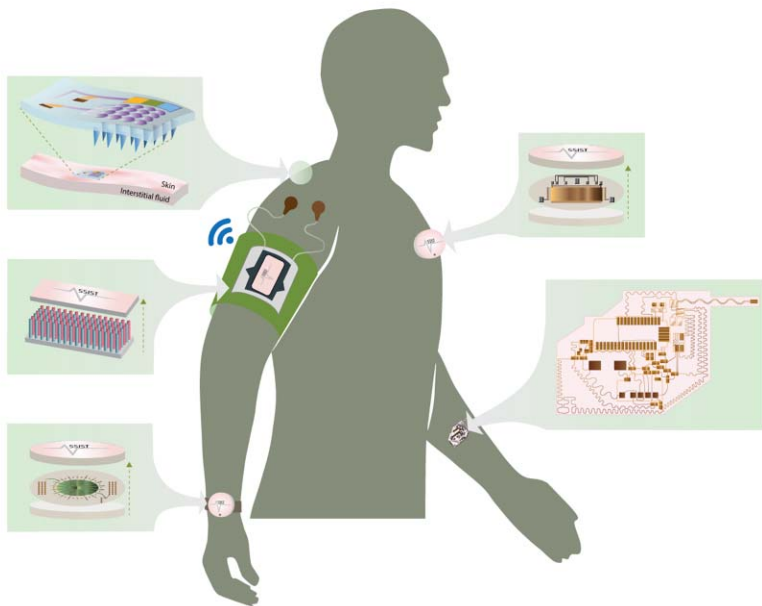
Dr. Shad Roundy
ASSIST PI, Assoc. Professor University of Utah



NC STATE UNIVERSITY

Transformative Technologies for Personalized, Vigilant Health Monitoring

Center Vision: to create self-powered sensing, computing, and communication systems that enable data-driven insights for a smart and healthy world.



- Wearable, Implantable or Injectable
- Wireless and comfortable
- Physiological, biochemical and environmental sensors
- **Self-powered (battery-free)**
- Informative, with continuous data
- Artificial Intelligence

Innovation Ecosystem



Advancing use case-driven, market-relevant research toward commercialization



Multidisciplinary Engineering:
Electrical, Computer, Chemical, Mechanical
Biomolecular, Biomedical, Textiles, Materials

University research,
faculty & students



Industry
partners



User &
caregiver
community



Key ASSIST Faculty Members



Veena Misra
Co-Director



Alper Bozkurt
Co-Director



Amay Bandodkar



Shekhar Bhansali



Benton Calhoun



Michael Daniele



Michael Dickey



James Dieffenderfer



Xiaomeng Fang



Wei Gao



Warren Jasper



Yaoyao Jia



Xiaoning Jiang



Edgar Lobaton



Stefano Menegatti



Amanda Mills



Ömer Oralkan



Mehmet Öztürk



Spyridon Pavlidis



Vladimir Pozdin



David Ricketts



Shad Roundy



Nitin Sharma



Koji Sode



Martin Thuo



**Susan
Troller-McKinstry**



**Abraham
Vázquez-Guardado**



Orlin Velev



Douglas Werner



Yong Zhu

Industry Members and Partners (Past & Present)

Donors/
Partners

Full



TOYOTA



Associate



Affiliate



Use Case Inspired Systems Driven Research

Use Cases

Asthma

Cardiovascular

Diabetes

Metabolic Status

Wound Monitoring/Healing

Aging

Alzheimer's /Dementia

Cough/Speech Detection

Gait / Fall Detection



Wearable Energy Harvesting and Storage

- Body heat & motion
- Biochemical
- Wireless (RF)
- Ultrasound



Low Power Sensor Systems

- Physiological
- Biochemical
- Environmental



Low-Power Circuits and Systems on Chip

- Low-power radios
- Low-power electronics
- Body-optimized antennas



Smart E-textiles and Flexible Materials

- Sensor integration
- Performance
- Manufacturability



Emerging Correlated Sensing Applications

- Hard/soft wearables
- Textiles
- Implantables
- Artificial intelligence



ASSIST Biomedical Systems

Health & Exposure Tracker Wrist Worn & Chest Patch

Reconfigurable for various applications

- Asthma • Mental Health • Aging • Behavior Tracking
- Cardiovascular Health

Multimodal sensing (wrist worn)

- Electrodermal activity (EDA)
- Gas sensing (environmental & skin vapor)
- Heart rate/Photoplethysmography
- Activity tracking
- Caloric burn rate
- Skin temperature
- Ambient temperature/humidity



Multimodal sensing (chest patch)

- ECG
- PPG
- Cough detection
- Activity tracking
- Ambient sound



Implantables/Injectables

- Multimodal sensing
- Bioresorbable
- Subcutaneous temperature
- Ultrasound energy transfer
- PPG
- Activity tracking



ECG Shirt



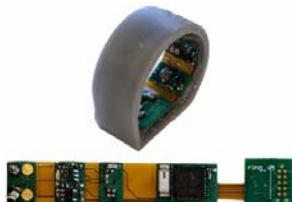
- Always-on operation
- Body-powered (heat)
- Dry electrodes
- Low-power radio
- Low-power circuits
- Wearable antenna

ECG Armband

- Comfortable, real-time ECG
- Ergonomic design with dry electrodes
- Optimized for motion artifacts
- Onboard IMU for contextual sampling
- Self-powered capability



Biophotonic Ring



- 12 Wavelength PPG
- Skin temperature
- Heart rate
- Total hemoglobin
- Hematocrit

Metabolic Tracker



- Sweat or interstitial fluid
- Biochemical markers including glucose, lactate, uric acid, pH
- Activity tracking
- Self-powered capability



Research
Portfolio

2024

Transformative technologies for personalized, vigilant health monitoring.



Visit us at
assistcenter.org

Energy Harvesting Technologies

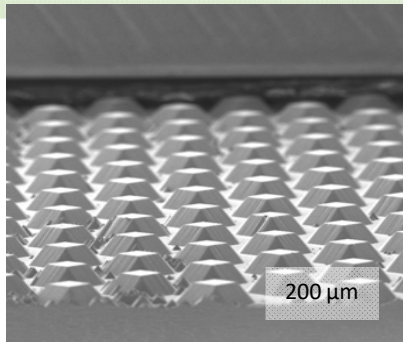
Body Heat

- Flexible thermoelectrics



Body Motion

- Piezoelectrics
- Flexoelectrics
- Liquid metal



EM Fields / RF

- Ambient Wi-Fi
- Electromagnetic
- Novel antennas on textiles



Supercapacitors

- Li ion capacitors
- High energy density
- Low leakage



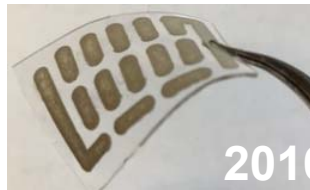
Timeline on ASSIST Flexible Thermoelectrics



2014

Dual Polyimide Substrates

- Excellent thermal design
- Challenging fabrication
- Poor Flexibility



2016

Silicone substrate with Ag Nanowire Interconnects

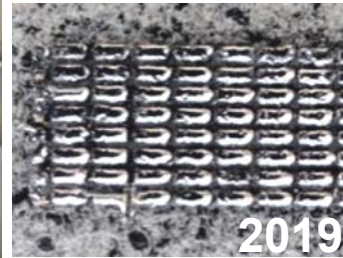
- Challenging Fabrication
- High resistance



2017

Silicone substrate with EGaIn Liquid Metal Interconnects

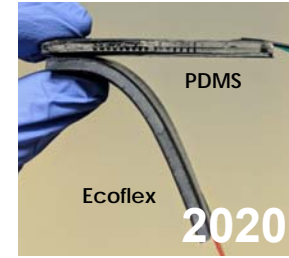
- Negligible Interconnect Resistance
- Excellent Selectivity



2019

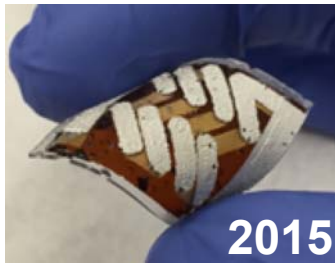
Low Thermal Conductivity Aerogel Doped Filler

- Reduced Heat Leakage
- 4.2X Higher Power Density



2020

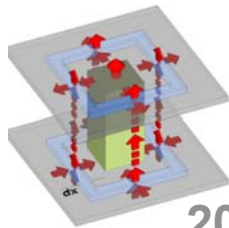
ASSIST TEGs at Consumer Electronics Show



2015

Single Polyimide Substrate

- Printed interconnects
- Improved Flexibility
- High resistance
- Poor lifetime



2016

Quasi 3-D Model

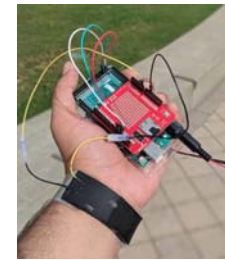
- Thermal/Electrical Model
- Highly Efficient & Accurate



2018

High Thermal Conductivity EGaIn Encapsulation

- Reduced Thermal Series Resistance
- Heat Spreading
- Improved Robustness
- 2.4X Higher Power Density



On-Body Characterization

- Data Acquisition
- Impact of Activity Level



Inclusion of Metabolic Rate in TEG Model



Networking / Promotional Events

EXTERNAL

1. **Smart Fabrics Summit** – NC State, 04/2023
2. **FEDTEX Conference**– NC State, 05/2023
3. **DeTech Summit** – Fayetteville, 07/2023
4. **SEMICON West / Flex** – San Francisco, 07/2023
5. **Defense Manufacturing Summit** – Red Springs, 09/2023
6. **MedTech Conference** – Anaheim, 10/2023
7. **Advanced Textiles Expo** – Orlando, 11/23
8. **ARPA-H REACT Workshop** – Denver, 11/23
9. **Medical Wearables Conference** – Online, 12/2023
10. **Animal Computer Interaction Conference** – NC State, 12/2023
11. **Consumer Electronics Show (CES)** – Las Vegas, 01/2024
12. **MD&M West** – Anaheim, 02/2024
13. **HIMSS** – Orlando, 03/2024
14. **FEDTEX Conference**– NC State, 05/2024
15. **TechTextil** – Raleigh, 08/2024

ASSIST

1. **Seminar Series (Weekly)** – NC State, Spring and Fall
2. **ASSIST Industry Day** – NC State, 03/2023
3. **Machine Learning Student Symposium**– Online, 04/2023
4. **ICoNS Symposium** – NC State, 05/2023
5. **Sensors, Biosystems and Analytics Converge**– NC State, 09/2023
6. **ERC Wide Workshop** – NSF HQ, 02/2024
7. **ASSIST Industry Day** – NC State, 03/2024
8. **ASSIST Implantables Workshop** – Online, 05/2024
9. **Convergence Accelerator Industry Day** – NC State, 05/2024
10. **ASSIST Industry Day** – NC State, 09/2024



ASSIST Summary

Technology Areas: *Sensors, Wearables, Implantables, Injectables, Flexible Electronics, Smart Fabrics, Artificial Intelligence, Energy Harvesting / Storage, Low Power Electronics*

- ▶ \$50M+ invested to-date through NSF, Industry and other funding agencies, since 2012
- ▶ 90+ Inventions (53+ patents)
- ▶ 10+ startups
- ▶ 700+ publications (H-index of 50)
- ▶ Workforce Development:
 - ❖ 105 PhDs, 27 MS and 96 UG
 - ❖ 115+ REUs (Research Experience for Undergraduates)
 - ❖ 40+ Capstone projects
 - ❖ 500+ K-12 participants in the wearable device challenge

ASSIST Start-ups



ASSIST Workforce Development



K-12 Outreach



Academic Programs

Professional Development

Undergraduate Research



Thank You

For more information:

Contact Ravi.Chilukuri@ncsu.edu

- or -

Visit assistcenter.org



ASSIST Webpage