



# DELTA Kick-off Meeting

*May 21-22, 2015*

**UCSD – Electrozyme**

## **ADAPTIVE TEXTILES TECHNOLOGY WITH ACTIVE COOLING & HEATING (ATTACH)**

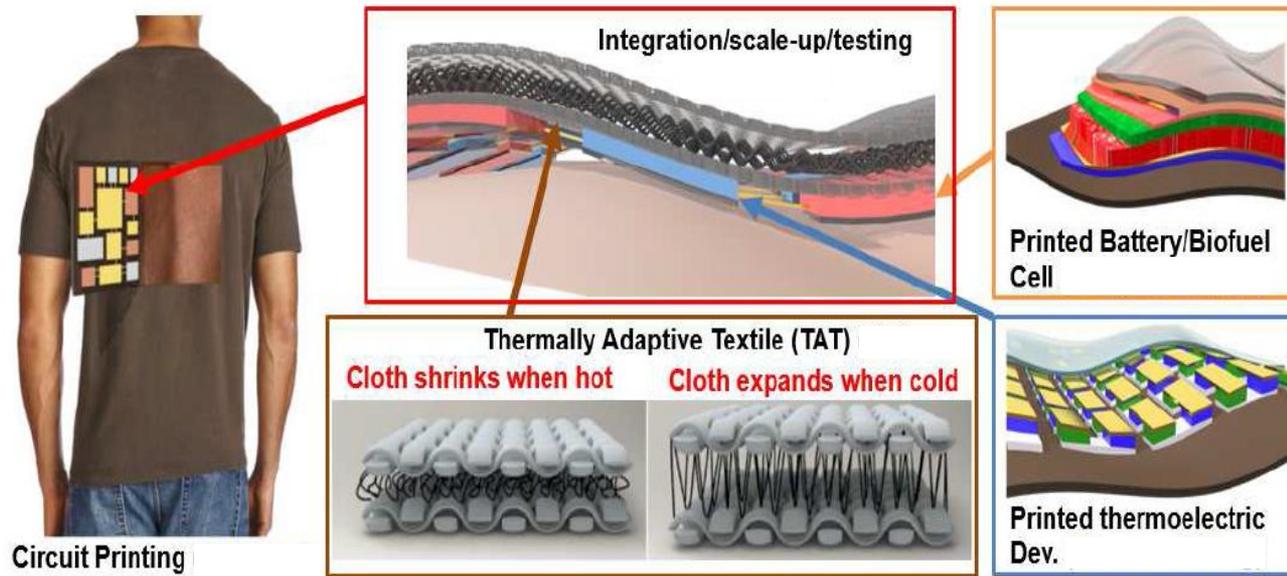
**PI:** Professor Joseph Wang  
**Co-PIs:** Professor Sungho Jin,  
Professor Renkun Chen,  
Professor Shirley Meng,

Dr. Joshua Windmiller (Electrozyme Inc.)

**Duration of award:**  
Three Years (5/2015 – 4/2018)



# Personal Thermal Management System



## Smart self-responsive textiles for autonomous passive heating and cooling

- Thermal regulation by changing textile thickness (air gap) and porosity in response to ambient temperature variation.

## All printed, wearable thermoelectric (TE) modules for active heating and cooling

- Provides individualized comfort and adjustable control
- Supported by low-cost printed electronics, textile-based biofuel-cell and flexible battery.

**Proprietary printing tecto printed TEC with  $ZT \sim 1.0$  and COP > 0.35.**

# Existing Technologies and Limitations

## Shape Memory Polymer based Textiles

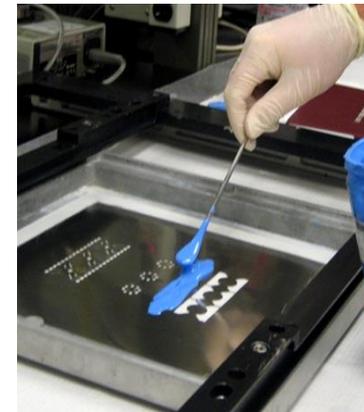
- Self-adaptive to environment
- Tunable thermal resistance
- Slow response to immediate change
- Independent of user's comfort

## Electronic and Thermoelectric Devices

- Responsive and rapid
- Bulk Thermoelectric,  $ZT > 1$
- Non-anatomically compliant, bulky, not wearable
- External power source

## Ours: Screen printing fabrication technology

- Low cost scalable mass fabrication
- Widely used in wearable devices (especially sensors)
- Compatible with diverse textiles, as well as with flexible and stretchable substrates
- Washability



To date, the two technologies have not been efficiently integrated.

Our integration of adaptive textiles and printable electronic devices will lead to an inexpensive and wearable personal thermoregulation device.

# Performance Targets and Validation Tests

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## Design Requirements for Broad Consumer Adoption

- Maintain skin temperature at comfort level of 93<sup>0</sup>F.
- Self-adaptive textiles response to wide, ambient temperature window of 66<sup>0</sup>F to 79<sup>0</sup>F.

## Validation for Adaptive Textiles and Printable, Active Heating/Cooling -

### Meeting the Milestones:

#### Printed Electronic Devices

Textile-based biofuel cells (4 mW/cm<sup>2</sup>)  
Aqueous battery (4 mW/cm<sup>2</sup>)  
or Li flexible battery (10 mW/cm<sup>2</sup>)  
TEC with ZT ≥ 1 and COP ≥ 0.35

#### Adaptive Textiles

Adjust linearly 0 to 10 mm  
to change in ambient  
temperature.

### **Without Compromising Comfort and Mobility**

(i.e., highly flexible)

### Validation tests

- Test the Individual components for their power and thermal performance.
- Systems integration and prototype evaluation.
- Simulated and actual on-body tests.

# Collaborations within DELTA Community



Joint design on adaptive textiles or marketing efforts with Electrozyme  
Integration of printed thermoelectrics and electronics to support their textile

Explore new opportunities and engage with commercial partners.

Collaboration on smart textiles, integrated electronics and conductive network, with other teams and agencies:

**Otherlab** – Passive Thermo-Adaptive Textiles with Laminated Polymer Bimorphs

**SRI International** – Wearable Electroactive Textile for Physiology-based Thermoregulation

**The University of California at Irvine** – Thermocomfort Cloth Inspired by Squid Skin

**Cornell University** – Thermoregulatory Clothing System for Building Energy Saving

Other Agencies such as **DTRA** and **DARPA**

A new scientific community specific to adaptive textiles, integrated electronics, and smart materials **to overcome the challenge of expensive**

**energy consumption due to heating and cooling the United States.**



Cornell University

**SRI International**

UNIVERSITY of  
CALIFORNIA  
**IRVINE**

