PROJECT CALL 7.0
TEAMING EVENT

DISTRIBUTION A: CLEARED FOR PUBLIC RELEASE

TEAMING EVENT STRUCTURE

- We will progress though each of the topics sequentially
- In-person presenters will start each new topic, followed by virtual attendees
- Each proposer will be allowed a single slide and one minute to pitch their proposal idea, capabilities, and / or type of partnership sought
- Please reach out to the presenters on Whova or directly after the event for questions or to discuss collaboration opportunities

TOPIC 7.1: ADVANCED PACKAGING APPROACHES FOR IC INTEGRATION IN FHE DEVICE

NEXTFLEX®

$450,000 maximum Institute funds / Up to an 18-month duration

Significant opportunities exist for development within the electronics packaging industry, as components continue to increase their capabilities, while shrinking in size. This enables system-on-chip architectures with high performance, multiple functionalities, all in significantly reduced footprints. Packaging approaches including heterogenous integration, 3D package-on-package component stacking, active interposers, and high-density interconnect component attach all show promise toward wide adoption of 2.5D and 3D electronic architectures. This topic seeks development and evaluation of advanced packaging approaches for IC integration in hybrid electronic devices, including those that are mechanically flexible, and based on FHE manufacturing processes, with specific interest in processes that can be transitioned to volume manufacturing-scale. Proposers must identify why the advanced packaging process is preferred over the state-of-the-art. Examples of possible approaches of interest include, but are not limited to:

a. High Density Flex Interconnects

b. Heterogenous Integration

Additively Fabricated Heterogenous Packaging Solution

Topic:

7.1 Advanced Packaging Approaches for IC Integration in FHE Devices

Description:

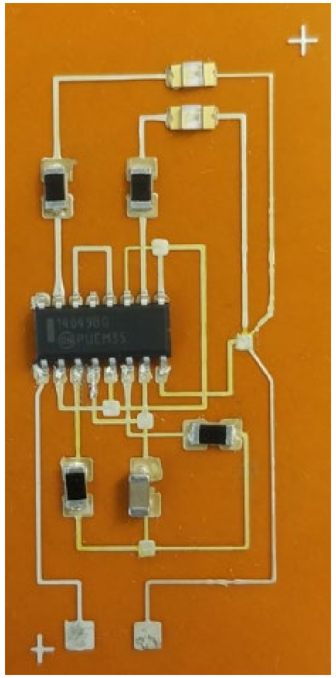
Program will focus on heterogenous packaging approaches using 2.5D and 3D integration of ICs in mechanical flexible form-factor devices incorporating capabilities of power management, signal processing, electronic sensing and computation.

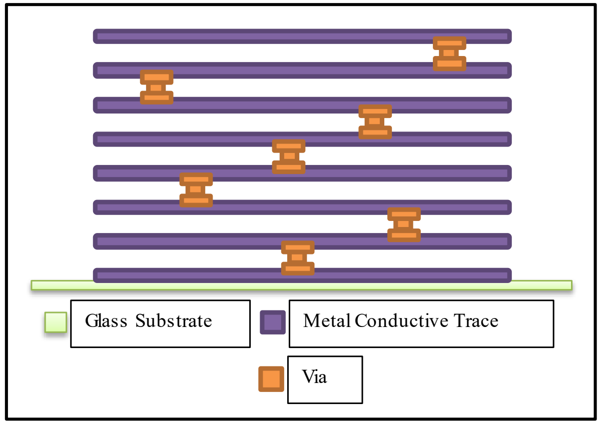
Background and Related Work Performed:

- Significant body of prior work development of interconnection methods for assembly of components on planar architectures with additively-printed circuits in PC6.4.
- Worked on characterization of flexible encapsulant properties in PC4.1, on printed traces in OPC 1.0, PC2.5, and antennas in PC 4.5.
- Prior work on development of packaging solutions for sustained high-temperature operation in automotive and defense applications.

Capabilities Sought in Potential Project Partners:

- Flexible Encapsulation Companies
- Solder Companies
- ACA Companies
- 3rd party Contract Manufacturers

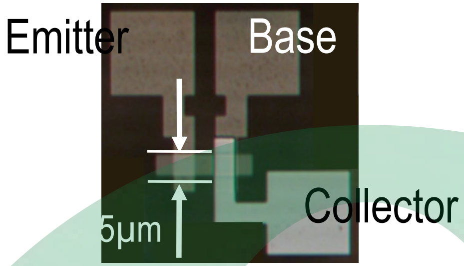


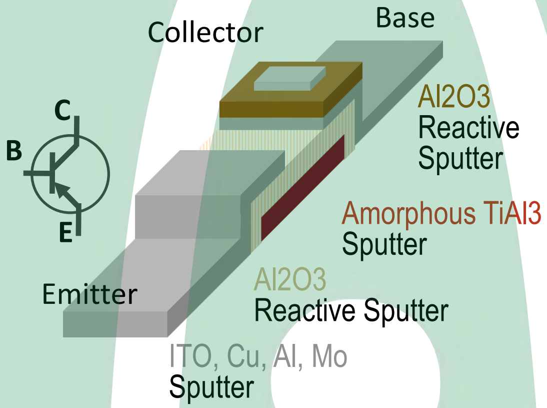


Contact: Pradeep Lall, lall@auburn.edu; (334)740-3424

MOTIVATIONS AND DRIVERS FOR PLP

		FOPLP (Die First)	FOPLP (Die last)	ED in substrate	ED in PCB	ED in flexible board
COMPONENTS INTEGRATION	Form factor: small footprint & low profile	✓	✓	✓	✓	✓
	Potential for integrating several components (SiP; SiB)	✓	✓	✓	✓	✓
	High potential for reducing I/Os due to design			✓	✓	✓
	High design flexibility & modularity	✓	✓	✓	✓	✓
ELECTRICAL PERFORMANCE	Less noise: reduced parasitics because of short interconnections	✓	✓	✓	✓	✓
	Better thermal management	✓	✓		✓	
	Larger bandwidth & high speed communication		✓			
	Possibility of high I/O count		✓			
	Shielding		✓	✓	✓	✓
PHYSICAL PERFORMANCE	High mechanical reliability	✓	✓	✓	✓	✓
	Physical protection of dice	✓	✓	✓	✓	✓
	Hermiticity					
	Protection against harsh environment			✓	✓	✓





Patents
US11069799 CN109564892A
KR20190018008A JP2019525461A
TWI678738B

Quantum Tunneling Thin Film Transistor

- No semiconductors
- Flexible materials, room temperature deposition

Amorphyx™ Simple For A Change 回到简单

Contact: John Brewer
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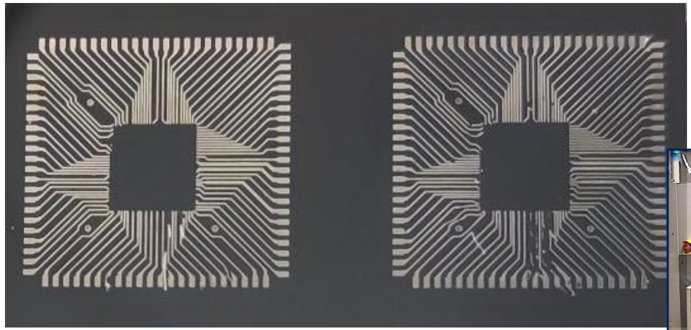
Topic 7.1 Title : Advanced Packaging Approaches for IC Integration in FHE Device



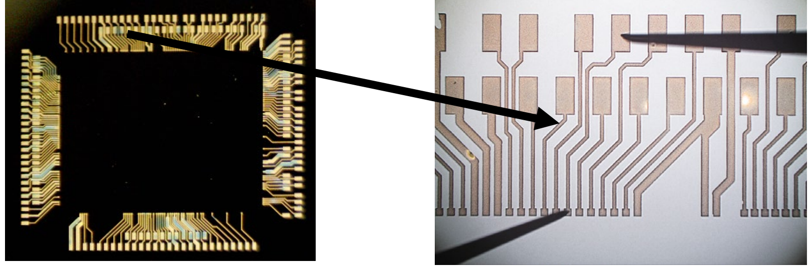
Nano & Micro high throughput Fully automated Printing System

Proposed Concept

- Printing compact and tightly integrated traces and interconnects that are complementary to conformal, flexible, and low-profile RF systems.
- Print dense and integrated interconnects for of sub-10 µm pitch breakout on flexible substrates, with sub 5 µm alignment and registration resolution.
- Using Northeastern’s patented printing technology on flexible substrates allows the printing of electrical interconnects and electronics onto a multi layer device.
- Significantly reduce the size of the interposer or PCB.

Background on related work performed

- Printing electronics and sensors using the fully automated and robotic printing with alignment and registration with sub 5 µm resolution.
- High-throughput printing of silver, copper, gold, or platinum micro and nano patterns down to submicron scale over large area.



Capabilities sought in potential project partners

- Seeking partnership with large manufacturers and end users for design and testing of the printed ICs.
- Seeking partners for field testing and development of necessary electronics and software for a complete system testing

Our work is conducted at the Northeastern University innovation campus and Kostas Center for Homeland Security which is an ITAR research facilities with DoD and DHS affiliated labs.

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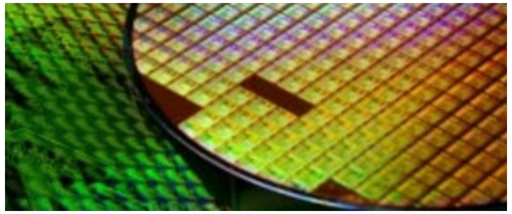
Northeastern University

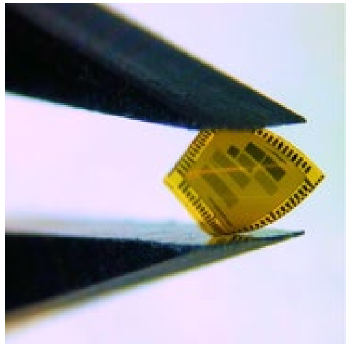
Silicon On Polymer (SoP) WLCSP Processing

WLCSP - Wafer Level Chip scale package
CSP – Chip Scale package

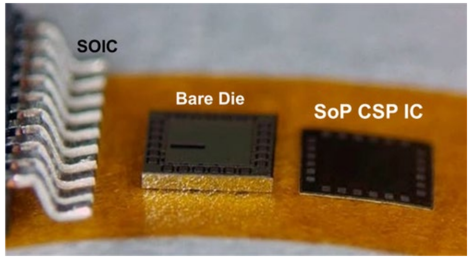
Silicon-on-Polymer (SoP) WLCSP processing and technology to produce the thinnest CSP ICs possible. FleX-C is a 2-sided protected SoP CSP process that produces ultra-thin ICs from IDM or foundry wafers.

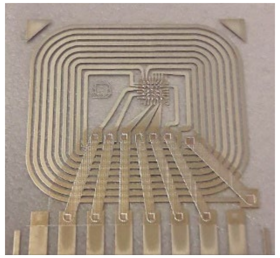


Silicon wafer



Grind till wafer is thin and encapsulated in polyimide to make it flexible





Develop interconnect on PET substrate

(FHE) Flexible Hybrid Electronics

Convert that into labels for different applications

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TOPIC 7.2: ADDITIVELY MANUFACTURED ELECTRONIC COMPONENTS AND DEVICES

NEXTFLEX®

$450,000 maximum Institute funds / Up to an 18-month duration

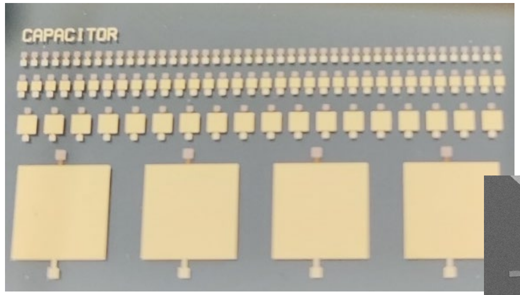
Traditional printed circuit board (PCB) manufacturing is poised for a paradigm shift as additive hybrid electronics approaches to manufacturing increase in capability, yield, and throughput. There is significant demand from traditional PCB manufacturers to integrate additive processes and tools into existing workflows, though further development and standardization is needed for process integration to be widely adopted by domestic manufacturers. This topic seeks to address this gap and advance the development and integration of additive tools for electronic component manufacturing. Example areas of interest relating to additive electronics manufacturing are listed below but are not restricted to those specified.

a. Reliability Testing and Standardization of Additively Manufactured Circuits

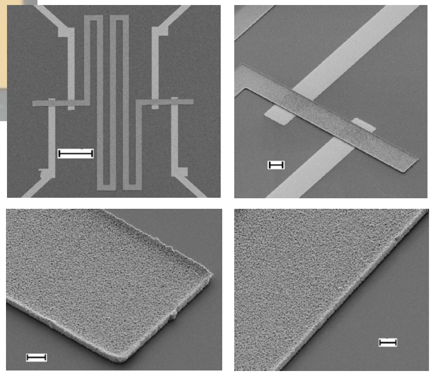
b. Manufacturing of Embedded Printed Passive Components

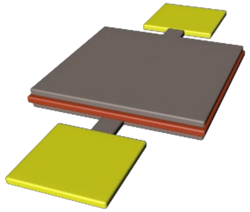
c. Digital Manufacturing of Reliable Multilayer FHE Electronics

Topic 7.2 Title : Additively Manufactured Electronic Components and Devices



Printed capacitors & resistors





Proposed Concept

- Development of additive tools for electronic component manufacturing. This includes printing passive and active components on interposers or boards.
- Printing passive and active circuit components with a sub 5 μm minimum resolution onto a single flexible circuit that combines microcontrollers and all balancing electronics onto a single microcontroller in package.
- Using Northeastern's patented printing technology on flexible surfaces allows for one to attach a bare silicon die package and print electrical interconnects electronic components such as capacitors, transistors, diodes and resistors monolithically.
- Reduce the size of the entire board or interposer by 5x.

Background on related work performed

- Printing electronics using the fully automated and robotic printing with alignment and registration.
- Demonstrated printing of passive and active components over large area.
- Printing capacitors, resistors, transistors and diodes

Nano & Micro Fully automated Printing System

Capabilities sought in potential project partners

- Seeking partnership with large manufacturers and end users. The printed system will be optimized to print these components monolithically at high rate.
- Seeking partners for circuit design and field testing of necessary electronics and software for a complete system characterization and testing.

Our work is conducted at the Northeastern University innovation campus and Kostas Center for Homeland Security which includes ITAR research facilities, DoD and DHS affiliated labs.

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Topic 7.2 Additively Manufactured Electric Components and Devices

Our Background

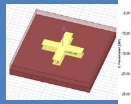
- Radome design, development, qualification, testing, production and repair
- Specialized electromagnetics and RF signature design and analysis
- Design for manufacturing and assembly (DFMA) expertise

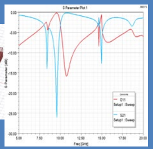
Our Related Work

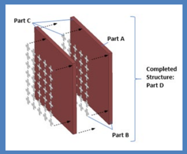
- PC6.8 Conformal, Multi-Layer FSS Structures for Radomes

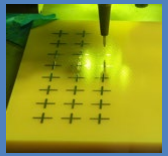
Other Related Work

- PC 4.5 (Boeing)
- PC 5.9 (Boeing)
- PC 6.9.2 (UMass)



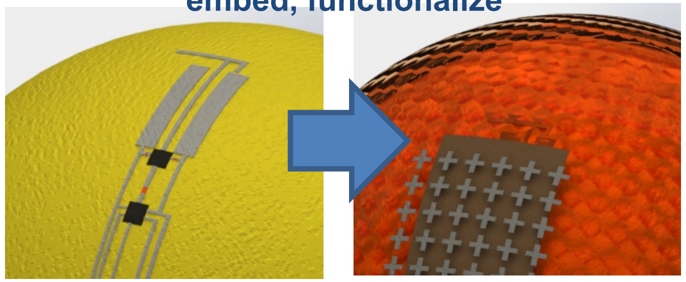






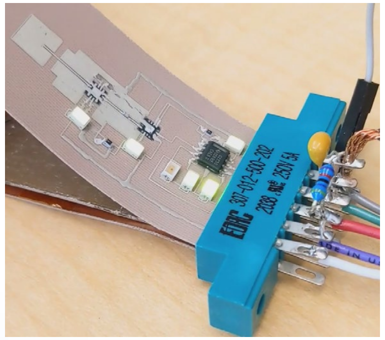
Proposal Concept: Multilayer Embedded Active RF Devices

- *Gap: Apply direct write and prepreg layup and encapsulation to embedded active circuitry*
- Conformal RF circuit (amp., balun integration) and FSS design
- Curved geometry implementation and encapsulation
- Construction implementation and performance testing



Capabilities Sought:

- Antenna/far field test capabilities
- Conformal print (aerosol jet, micropen, etc)
- Rapid tooling manufacture
- Airframe/UAV integrator
- Antenna design



GENERAL DYNAMICS
Mission Systems

Contact:
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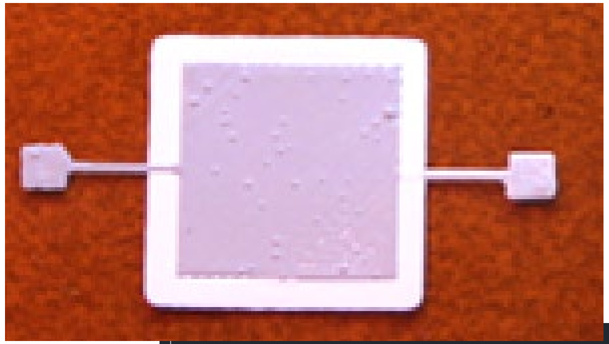
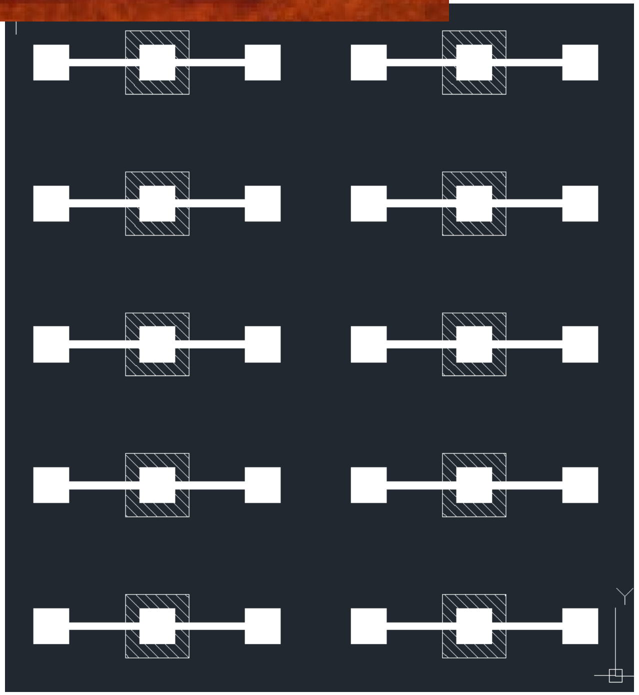
Credit: HEROES SLIMMER2 initiative, UMASS Lowell
BAA W911QY-15-R-0016 and W911QY-18-2-0006

Manufacturing Rules and Test-Levels for Yield-Reliability-Performance of Embedded Printed Passives

Topic:

7.2 Additively Manufactured Electronic Components and Devices





Description:

Additive manufacturing process-development for embedded printed passives to ensure a high yield, performance and reliability. Program will focus on reliability in the end application for fully additive manufactured components.

Background and Related Work Performed:

- Significant body of work in closed-loop control of additive process for the printing of passives including resistor, inductors and capacitors in PC65.
- Worked on the reliability of the flexible additive printed interconnects in PC2.5. Developed the z-axis interconnects and process-yield interactions in OPC1.0.
- Quantified the sigma-levels for a number of additive print processes and developed foundational data for defect-reduction.

Capabilities Sought in Potential Project Partners:

- Ink-Companies with offerings in dielectrics
- High conductivity and/or low-sintering temperature inks
- Flexible encapsulation materials companies.

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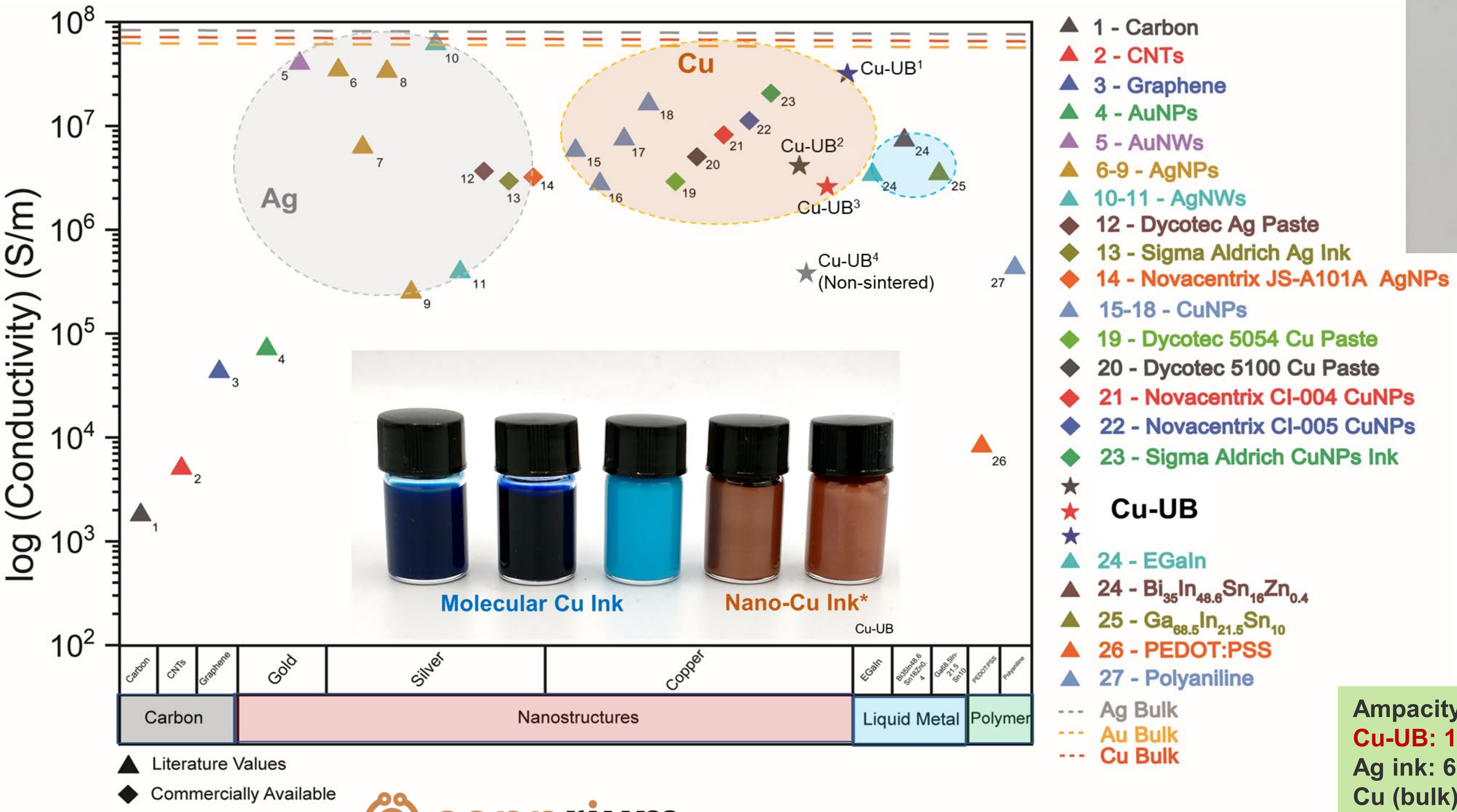
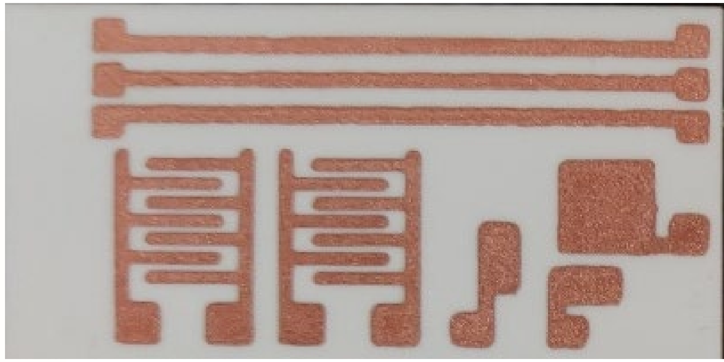
Printable Copper Ink Materials and FHEs for Broad Temperature Range

Shenqiang Ren; University at Buffalo – The State University of New York; shenren@buffalo.edu; 716-645-1431

University at Buffalo
The State University of New York



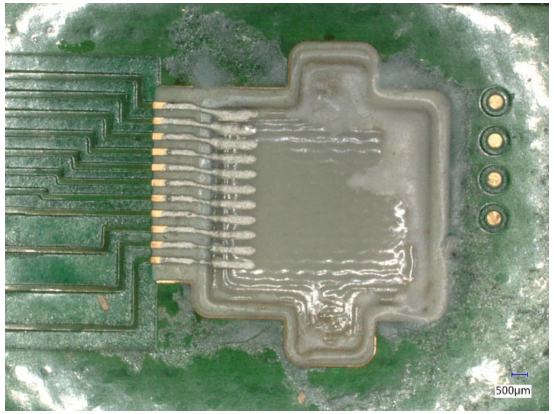


- Anti-Oxidation and Anti-Corrosion under Extreme Conditions
- High electric and thermal conductivity
- Temperature coefficient of resistance (Low)
- High Current Density Carrying (Ampacity)

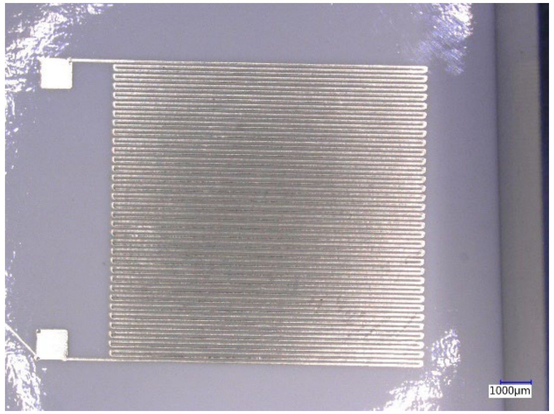
Ampacity	Temperature Coefficient α
Cu-UB: $1.25*10^9$ A/m²	Cu-UB: +0.0016 °C⁻¹
Ag ink: $6.2*10^8$ A/m²	Cu (bulk): +0.0043 °C⁻¹
Cu (bulk): $6*10^{10}$ A/m²	Ag (bulk): +0.0041 °C⁻¹

copprium https://www.copprium.com/

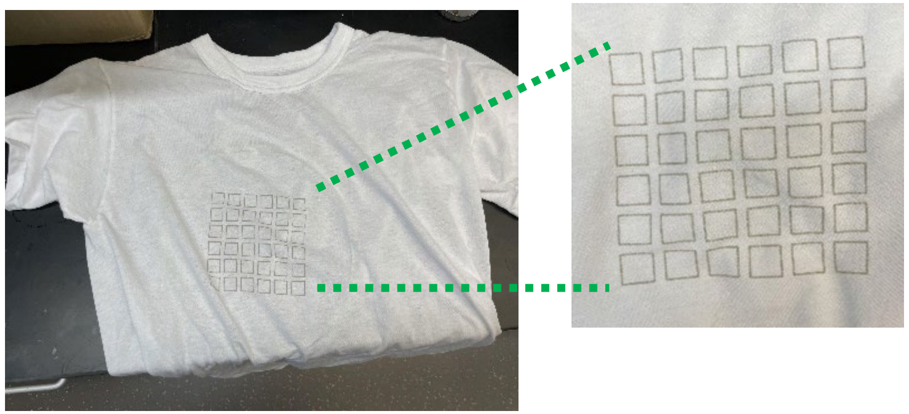
PC 7.2: Additively Manufactured Electronic Components and Devices



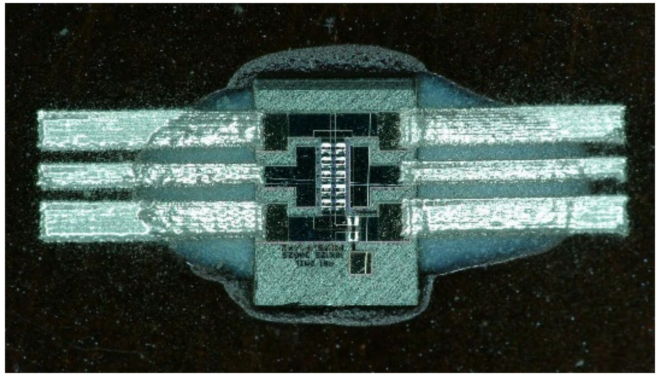
Additively manufactured conformal interconnects printed in nScrypt 3DN-300 printer



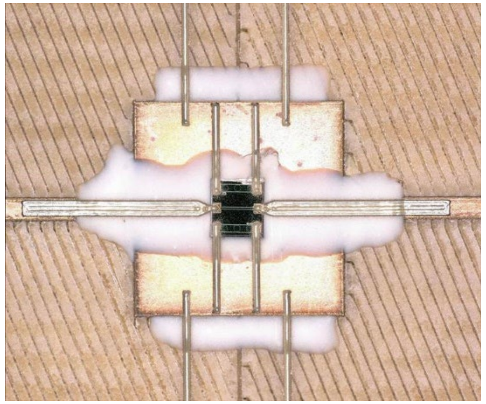
Meandering resistor on a photopaper printed in IDS Nanojet aerosol jet printer using the JS-A101 silver nanoparticle ink.



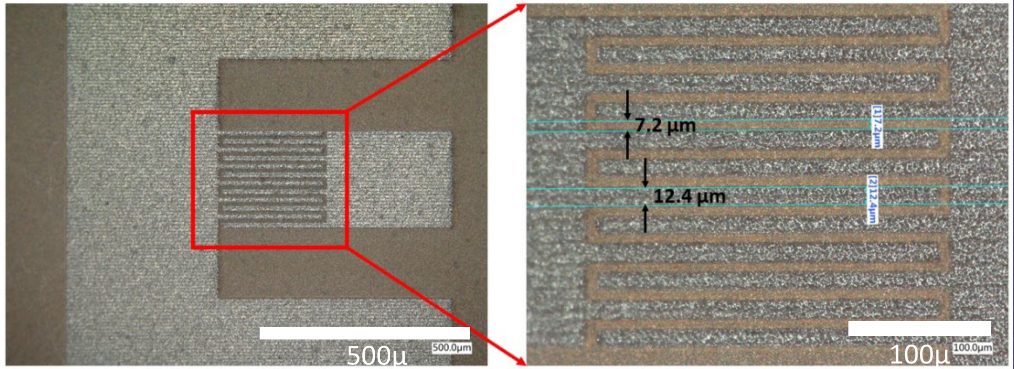
Printed metasurface on T-shirt printed in Nordson automatic dispensing system using the Dupont PE876 silver ink.



Printed (in Optomec AJ5X)coplanar waveguide connected to the high electron mobility transistor. The dielectric ramp printed using an inhouse UV ink.



Bare die attenuator chip on copper-clad dielectric with aerosol-jet printed silver interconnects. Inhouse developed dielectric filets printed by syringe dispensing.



Selective laser sintered interdigitated capacitor on inhouse developed Ag-BST convertible ink substrate. Selective laser sintering performed in 405 nm laser in Heidelberg mask writer.

Alkim Akyurtlu
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Magnetically-Aligned Microelectronic Interconnect Solutions

Technical Advantages

Need versatile faster, low-cost, higher performance interconnect solutions for Flexible Hybrid Electronics that overcome limitations of conventional solder, epoxy, wire-bonding, and ACA /ACF

Multifunctional ZTACH® ACE - Z-axis Anisotropic Conductive Epoxy

- **Magnetic processing** of conducting particles in 10 seconds; overcomes standard high temperature-high pressure packaging limitations
- **Ultrafine pitch and Non-Planar Morphology** capabilities with highest input/output interconnect density on the market
- **Multipath cooling**; thermal dissipation via columns provides highest functionality and longevity
- **Proven Reliability** - Robust and Rugged for extreme conditions
- **Processed materials provides structure -** outstanding adhesion & shear strength; high vibration resistance & shock tolerance
- **Demonstrated low-cost fine pitch / high yield**; replacement for conventional wire-bonding and flip-chip; suitable for advanced 3D packaging

Anticipated Benefits *and* Applications

Military: Large SWaP-C benefits for variety of DoD microelectronic needs; especially for stressing Aeronautics, Space, and Warfighter applications

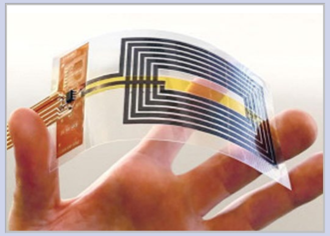
- **Over 2X smaller footprint** than comparable wire-bonding; lower weight
- **Thinner and higher performance** than comparable flip-chip
- **High RF bandwidth** performance [1-90 GHz tested]
- **Excellent radiation hardness** [DoE SBIR Ph1: 100 Mrad]
- **Excellent cryogenic cycling** temperature performance [DoE SBIR Ph2]
- **Low costs** & overall ease of use [63% less than wire-bonding]

Commercial: High volume scalability with Standard SMT equipment provides low-cost alternative to conventional materials and methods

Multifunctional ZTACH® ACE & reduced-step processing technology enables faster, cheaper, and higher performing interconnects for packaging microelectronic systems, flexible hybrid electronics, etc.

Technical Description

- **ZTACH® ACE utilizes electromagnetic alignment of highly conductive ferromagnetic particles** dispersed in an epoxy matrix
- **Scalable production via standard SMT** processing equipment utilizing specialized Magnetic Pallet;
- **Rapid single-step assembly of mixed multi-component at low temperature** or alternatively with UV cure; also eliminates need for separate underfill materials & steps.



Goals *and* Collaboration

Goals are to demonstrate rapid prototyping and high volume processing capabilities to include characterization, testing, and evaluation aligned with broad FHE applications supporting military and commercial products.

Collaborators: We welcome device manufacturers / contract manufacturers for engineering support, M&S, thermal analyses, and environmental testing for NextFlex PC Topics 7.1-7.7 for microelectronic applications in aerospace, automotive, medical wearables, and beyond.

Madhu Stemmermann, CEO
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TOPIC 7.3: IMPROVED ENVIRONMENTAL SUSTAINABILITY OF ELECTRONICS WITH FHE MANUFACTURING

$450,000 maximum Institute funds / Up to an 18-month duration

FHE manufacturing technology presents opportunities to adopt materials and processes that are friendlier to the environment and ecologically sustainable. The full product life cycle from design to recycle / disposal all directly and indirectly have an environmental impact that needs to be evaluated so that cleaner, more sustainable materials and methods can deliver a near-term impact. This topic seeks to address sustainability in FHE and printed electronics manufacturing, which is an area with rapidly growing interest, but limited foundational efforts that establish the current state-of-the-art. Examples of possible approaches of interest include, but are not limited to:

a. Full Product Life Cycle Modeling for FHE and Printed Electronics

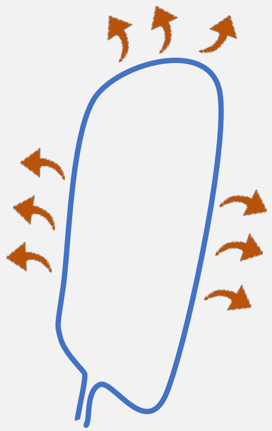
b. Repair of Printed FHE Devices for Reduced E-Waste Generation

c. Physical Integration of Flexible Batteries for Improved Electronics Recycling

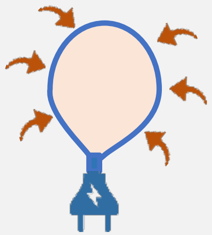
7.3 Improved Environmental Sustainability of Electronics with FHE Manufacturing

To reduce battery consumption in the world that needs new energy delivery system to enable wire-free and battery-free electronics.

Transmitter Loop (Tx)	Receiver Loop (Rx)



- **Meta-wire loop**



- **Wire-free and Battery-free Flexible Electronics (Stickytronics™)**

RESONATE THE WORLD

Jeff Yen, Ph.D

Co-founder & CEO

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Bio-Degradable Additive Print Structures with Decouplable Interconnection

Topic:

7.3 Improved Environmental Sustainability of Electronics with FHE Manufacturing

Description:

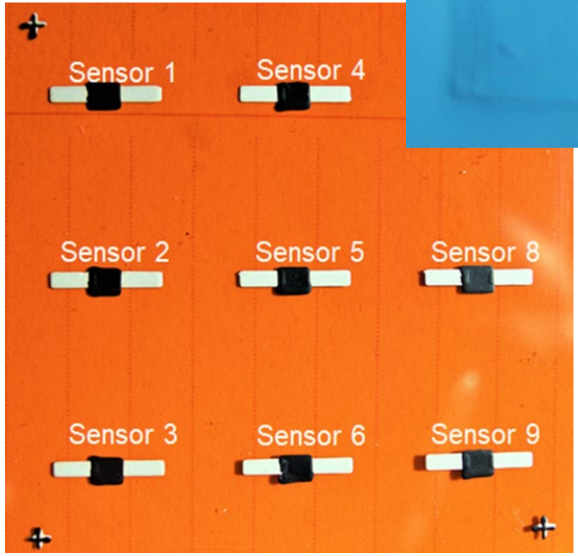
Additive print processes which rely on the use of bio-degradable materials for reduction of e-waste generation. Use of methods for end-of-life decoupling for appropriate recycling of sub-parts. Low-temperature processing for reduction in carbon footprint.

Background and Related Work Performed:

- Significant body of work on the study of reliability, performance and state-of-health degradation on thin-flexible batteries with permanent interconnects in PC5.6.
- Worked development of < 100C low-temperature processing for interconnection and additively printed circuits in PC6.4.
- Prior work on development of environmentally friendly packaging solutions including leadfree solders, halogen-free encapsulation.

Capabilities Sought in Potential Project Partners:

- Companies with bio-degradable inks and dielectrics
- Separable interconnect solutions
- Environmentally friendly power-source solutions



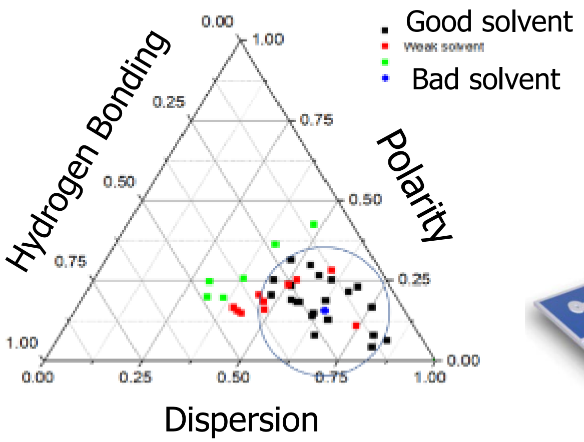
Contact: Pradeep Lall, lall@auburn.edu; (334)740-3424

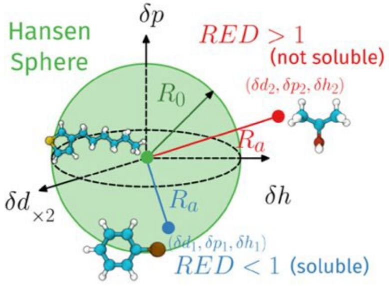
CAPABILITIES IN SUSTAINABILITY

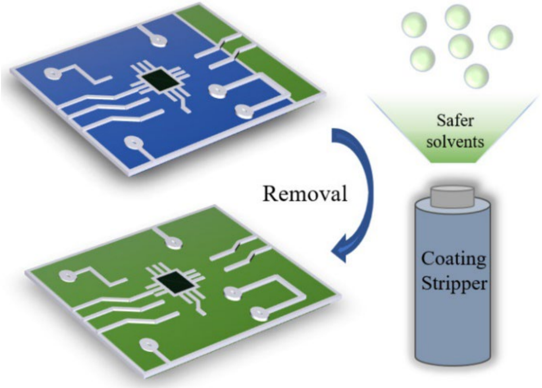
- Removal of conformal coatings on electronics to enable re-manufacturing
- Process and characterize biodegradable and/or recycle materials
- Designing systems with safer solvents—alternatives assessment

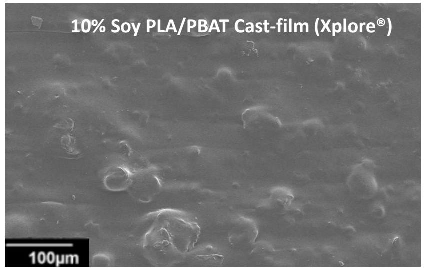
Using safer solvents for re-manufacturing electronics

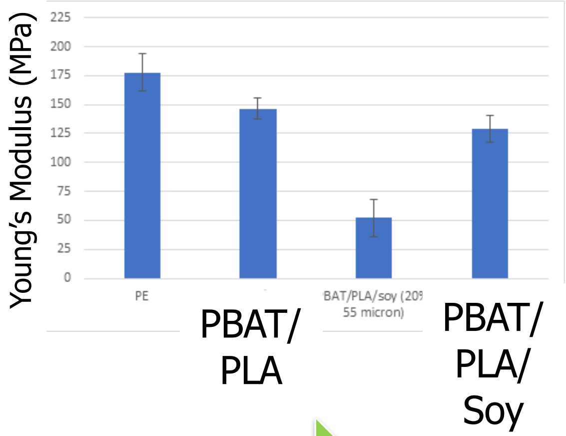
Biodegradable Material Processing











- Prof. Grace Chen; GraceWanTing_Chen@uml.edu

Techno-Economic Feasibility/Safety Assessment

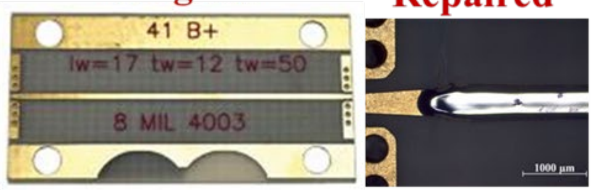
PC 7.3: Sustainment of RF PHE via Additive Repairs: Qualification

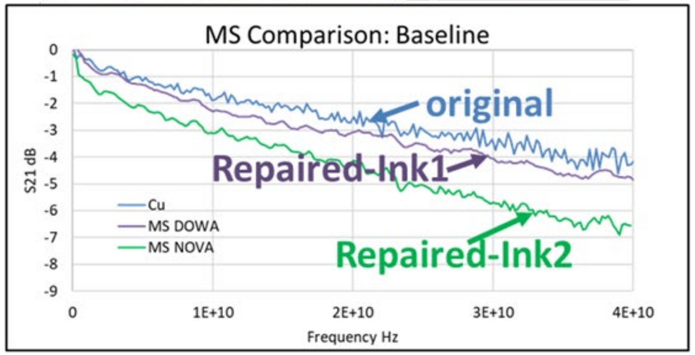
NextFlex PC6.2 Goals & Accomplishment

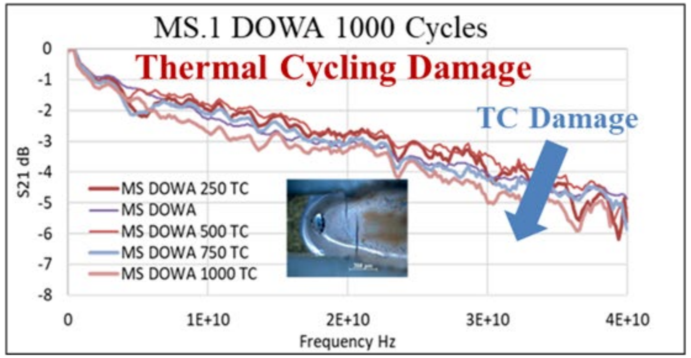
Use additive field-repairs for a transformative sustainment solution

Microstrip & Coplanar Wave Guide

Original | **Additively Repaired**



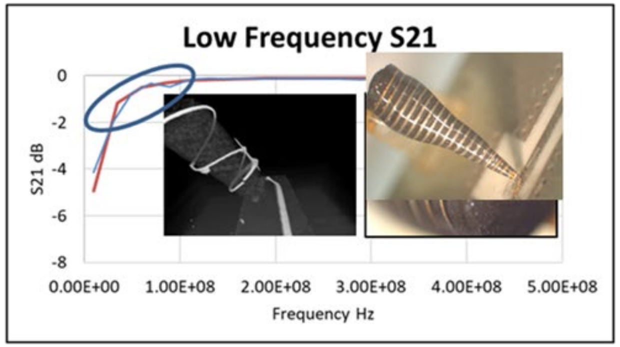




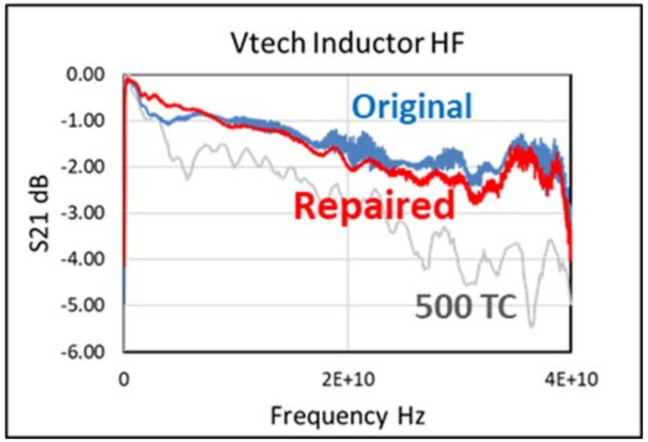
Printed Inductors

Additive Repair

Handling Damage: After repair

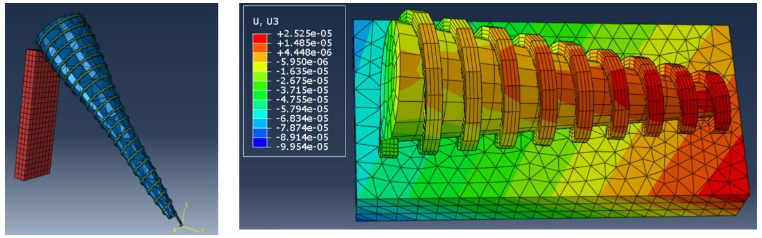


Thermal Cycling Damage



NextFlex PC7.3 Proposal

1. Develop accurate physics-based acceleration models for environmental testing conducted in PC6.2 on additively printed and additively repaired FHEs:
   - Thermal cycling damage
   - Temperature-humidity damage



2. Leverage PC6.2 accomlishments to conduct physics-based qualification of additively repaired RF PHEs for additional life cycle conditions:
   - Uniaxial/Multiaxial Vibration
   - Combined vibration/temperature
   - High-G Drop testing (up to 100,000 Gs)

calce Center for Advanced Life Cycle Engineering **SMIEL** Soft Matter Interfaces & Energy Lab

Abhijit Dasgupta
dasgupta@umd.edu

UNIVERSITY OF MARYLAND

TOPIC 7.4: MANUFACTURING OF SOFT AND STRETCHABLE ELECTRONICS

$450,000 maximum Institute funds / Up to an 18-month duration

Soft electronics show significant promise in several application spaces including wearable and textile-integrated electronics, soft robotics, and human-machine interfacing. This topic seeks development and evaluation of manufacturing techniques that will further enable soft and stretchable electronics. Examples of possible topics include:

a. FHE Interfaces for Rigid, Flex, and Stretch Components

b. 3D Printing of Active Soft Materials with Embedded FHEs

c. Manufacturing Soft Embedded Microchannels for FHE Devices

ELMNT© Stretchable Conductor

Seeking teams for 7.4, 7.7, and 7.8 to ***develop supporting capabilities*** *(interconnects, substrates, manufacturing) for liquid metal inks.*

Current technical needs:
- *Robust interconnect solutions*
- *New printing techniques*
- *Field testing and vetting*

UES Excellence in Science & Technology

Stretchable Advantages

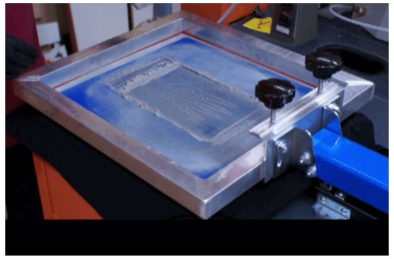
LM ELMNT™

Advantages:
- *Multiple printing paradigms*
- *Multiple viscosities/formulations*
- *Low hysteresis*
- *Low resistance change*
- *Cost conscience*
- *Highly strainable*
- *No heat required*

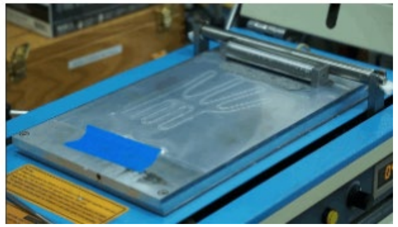
Test	Properties
Conductivity	2,000-14,000 S/cm
R/R0 at 100% strain	<1.5
R/R0 at 150% strain	<1.75
Resistivity change 10k cycle from 0-100% strain	<5%
Viscosity range	10-100,000 cP

Versatile Printing

ELMNT.ST
Screenprinting

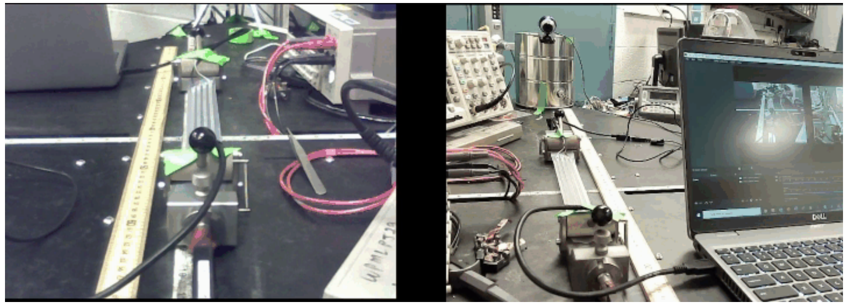


ELMNT.BA
Blade coating

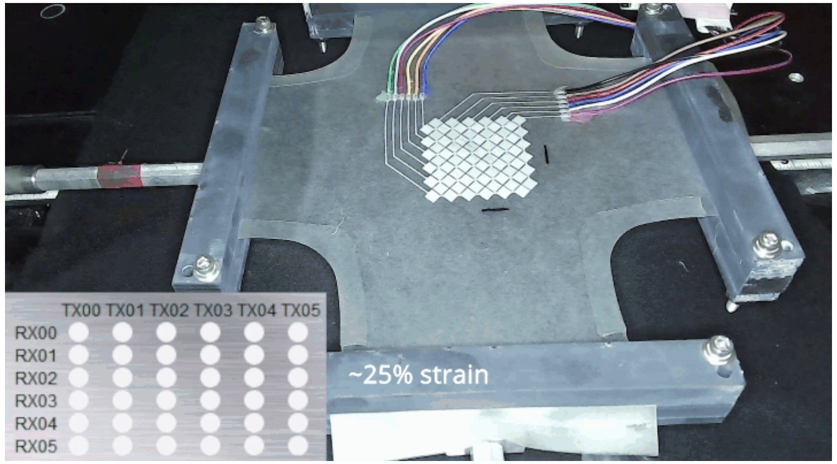


Device Demonstration Examples

Stretchable USB



Capacitive Touch



POC: **Eliot Gomez** **egomez@ues.com**

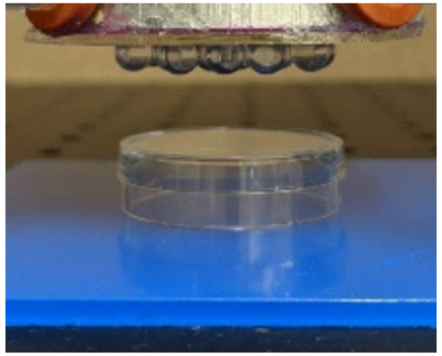
Kevin Turner – U. Pennsylvania – kturner@seas.upenn.edu, 215.573.7485

7.4 - Manufacturing of Soft and Stretchable Electronics

Tunable stiffness soft robotic components realized via integration of FHE and shape memory polymers (SMPs)

FHE backplane with heaters, sensors, etc. + Printed shape memory polymer = Intelligent tunable stiffness element

Applications: Grasping, reconfigurable robots, ..

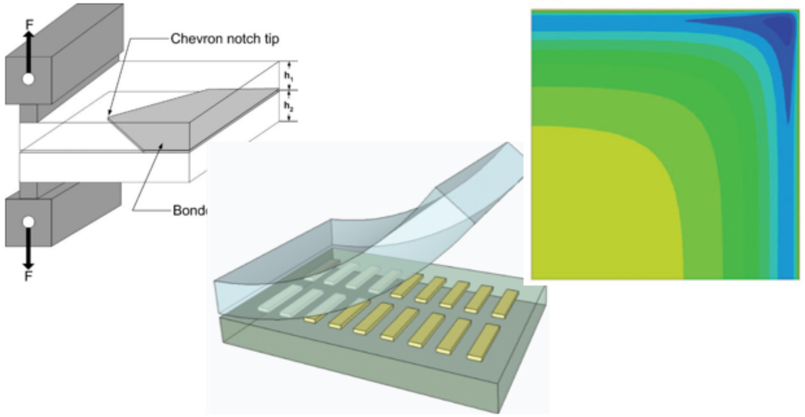


Seeking **partners** with interests in

- Soft robotics
- Design (EE)
- Printing of SMPs

Core capabilities

- Mechanics of FHE devices/processes (experimental and computational)
- Bonding; thin die transfer processes
- Active/tunable mechanical materials (stiffness, adhesion, friction)



Other topics of interest:

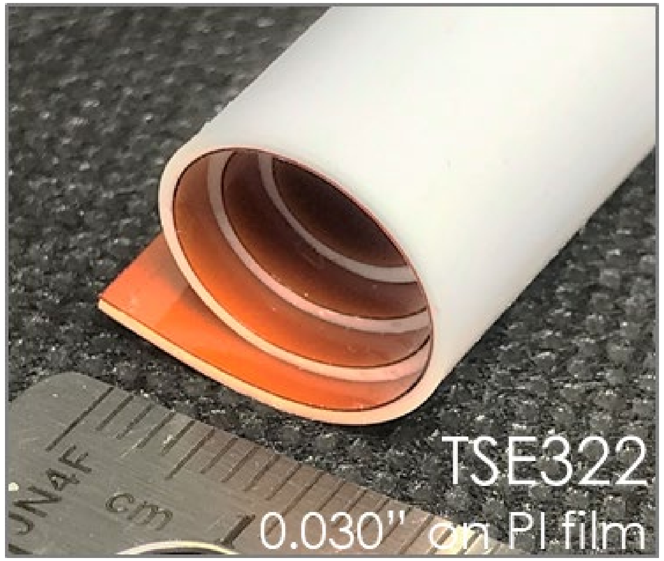
7.1 - *Advanced Packaging Approaches* – heterogenous integration/interconnects - metal-metal bonding via thermocompression, transfer/handling of ultra-thin dies, alignment strategies

7.7 - *Wearable Human Monitoring / Interface Demonstrator*

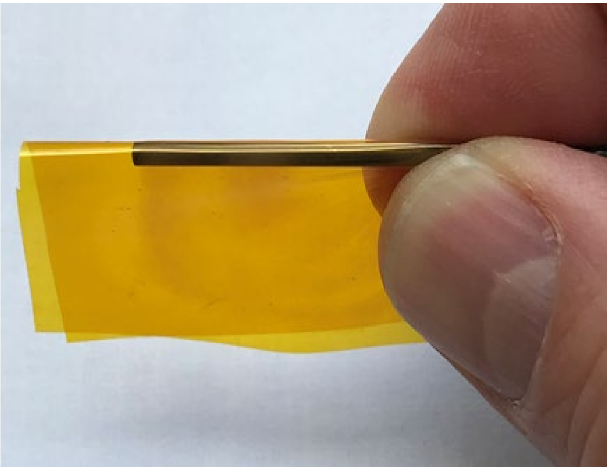
Why Momentive Silicones?

MOMENTIVE™ inventing possibilities

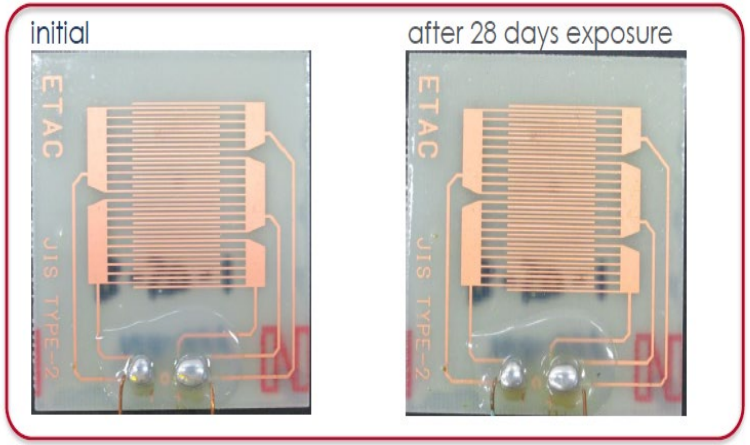
- Legacy Formulations
- Biocompatibility
- Various Cure Profiles
- -115 to 260 °C stability
- Electrically/Thermally insulative to conductive
- Low Volatility
- Transparent to opaque
- Flowable to paste consistency
- Adhesion to common flex substrate
- Suitable as stretchable substrates(fatigue tested)
- Environmental reliability - Salt spray / UV stable / Atomic oxygen

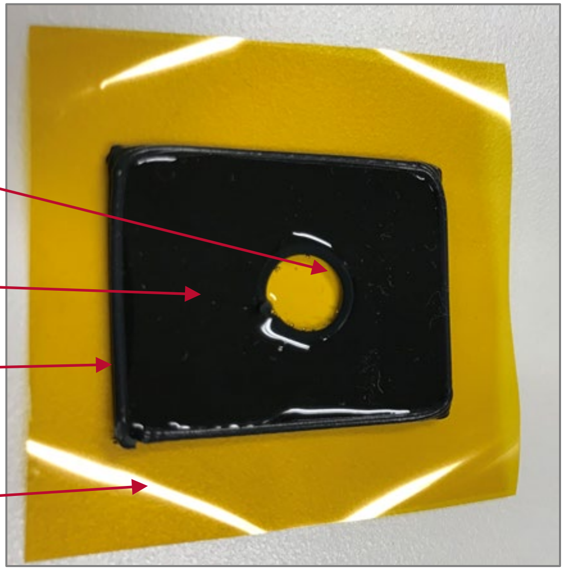


ECC3051S conformal coating on Kapton HN survived 1/16" mandrel bend test



No corrosion to copper traces with ECC3011 & 3051S conformal coatings





Vincent Malave

vincent.malave@momentive.com

TOPIC 7.5: ENHANCED DIELECTRIC MATERIALS & MANUFACTURING METHODS FOR FHE DEVICES

$450,000 maximum Institute funds / Up to an 18-month duration

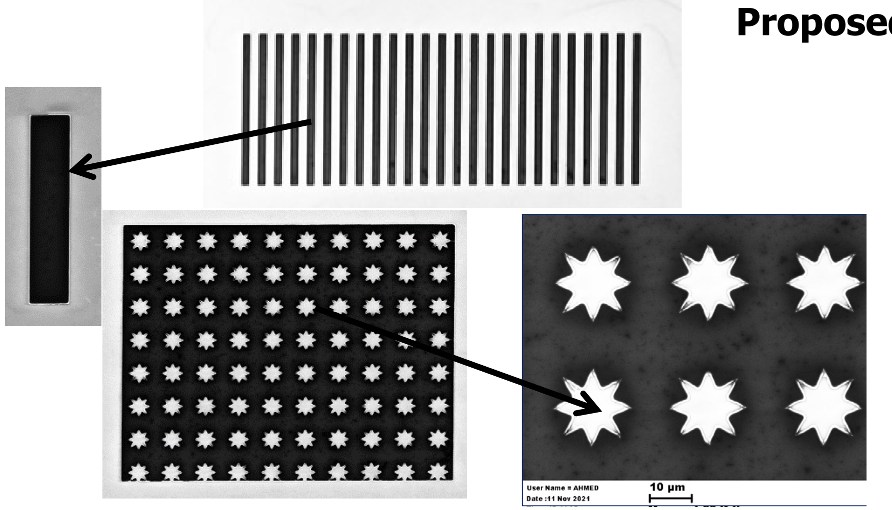
FHE require the use of materials (substrates, conductors, dielectrics, encapsulants/overmolds) that can reliability and predictably bend/flex depending on their intended application. This topic seeks demonstration and evaluation of dielectric materials and associated manufacturing workflows that will advance the space of a specific application field by utilizing advanced material sets with performance metrics not previously shown by FHE systems. This project will help to (a) define material properties to enable FHE at low and high-volume manufacturing, (b) expand material database inputs to include "real world performance" data and (c) develop product design guides which define materials, printing processes, and post-processing and assembly methods. Performance demands and packaging requirements are highly depended on their intended application/use-case and must be clearly defined by proposers. Example areas of interest are listed below but proposers are not restricted to those described.

a. Printable Dielectric Materials for RF Packaging

b. Encapsulation of Thin Dies on Flex / Stretch Substrates

Topic 7.5 Title : Enhanced Dielectric Materials & Manufacturing Methods for FHE Devices

Northeastern University



Printed Dielectric channels (10x200 microns) and other patterns

Proposed Concept

- Print low and high dielectric constant materials that are UV curable, or cure at a very low temperature (<160 C) that can optimized for printing.
- Materials will be printed with a microscale thickness with a minimum feature size between 5-10 micron.
- Use Northeastern's patented printing technology on flexible surfaces to shrink printed FHE boards by printing ultra fine resolutions logic gate circuit components.

Background on related work performed

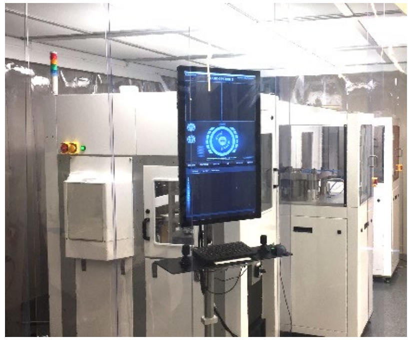
- Printed dielectric patterns that are cured at a low temperature or using UV curing.
- Printed dielectrics have been already been used and integrated in printed passive and active devices, logic gate circuit with fine resolution using a fully automated printing system with built-in alignment and registration capabilities.
- Realized high-throughput printing micro nanoelectronics.

Capabilities sought in potential project partners

- Seeking partnership with large manufacturers and end users with use case for end applications.
- Seeking partners for circuit design, field testing and reliability studies.

Our work is conducted at the Northeastern's innovation campus and Kostas Research Center that includes an ITAR research facilities.

Nano & Micro Printing System



Ahmed Busnaina | a.busnaina@northeastern.edu | (617) 373-2992 |

PC 7.5: Enhanced Dielectric Materials & Manufacturing Methods for FHE Devices

In –House Dielectric Inks and Applications

- Planarizing layers
- Insulating Layers
- Gasket materials
- Stabilization for resistive inks
- Low Loss Photopolymers
- Bare-Die integration

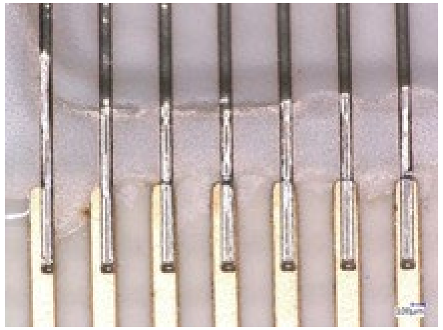
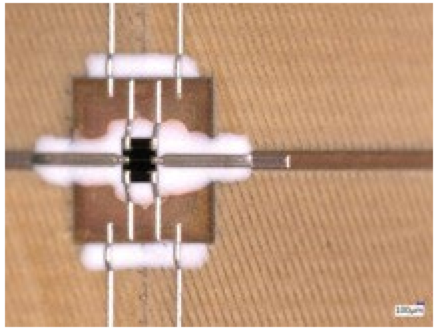
Future Work

- Explore ultrasonic atomization, also plan to add high dk nanoparticles.
- Analyze the interplay between boron nitride and crosslinker loading and cured film modulus, for the purpose of increasing printed silver interconnect throughput.
- Further work on lowering dielectric losses.

Alkim Akyurtlu
Alkim_akyurtlu@uml.edu

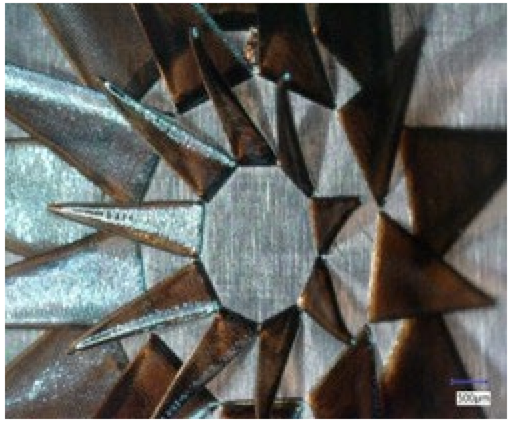
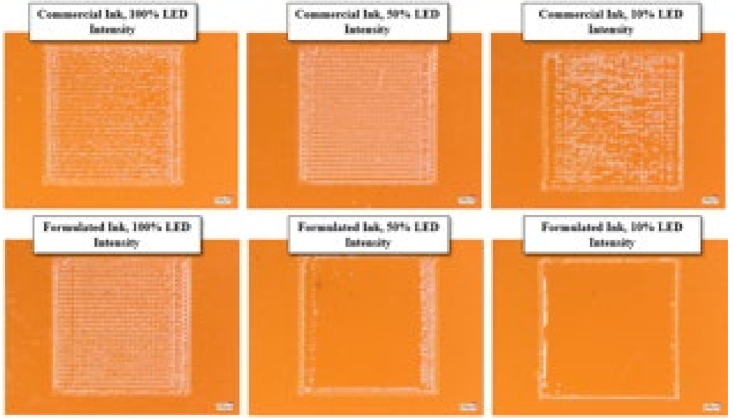
UV Curable Boron Nitride Nanocomposites

- For direct ink writing, planarizing FDM printed surfaces, filling gaps between circuit board components
- Submitted 2 patent applications, one in September 2021 (63/254,230) and one in October 2021 (17/515,870).
- Plan to analyze the interplay between boron nitride and crosslinker loading and cured film modulus, for the purpose of increasing printed silver interconnect throughput.


Photopolymer Dielectric for Aerosol Jet Printing

- For printing smooth dielectric layers or 3D microstructures over planar or conformal surfaces
- Submitted 2 patent application in July 2021 (17/372,907)(17/37,3083) and a manuscript to Additive Manufacturing on 2/21/22.

TOPIC 7.6: MANUFACTURING OF FHE-ENABLED AUTOMOTIVE COMPONENTS

$450,000 maximum Institute funds / Up to an 18-month duration

Automotive platforms increasingly use electronics for several critical functions including communications, guidance, charging, operator interaction, and the acquisition of signals from sensor networks. Significant opportunities exist for adoption of FHE technologies to enable these functions by seamless, fully integrated systems. This topic seeks demonstration and evaluation of FHE manufacturing technologies that are highly relevant to the automotive industry. Proposers should describe the performance and reliability requirements associated with the described process and/or applications. Alignment of testing protocols with existing automotive standards is highly desired. Projects with automotive original equipment manufacturers (OEMs) and/or tier suppliers are strongly preferred. Examples of possible topics of interest include, but are not limited to:

a. Evaluation of In-Mold Electronics Manufacturing Processes and Reliability

b. Film-on-Structure FHE Integration for Automotive Applications

c. Connectors for Printed Electronic Circuits for Module-to-Module Interconnection

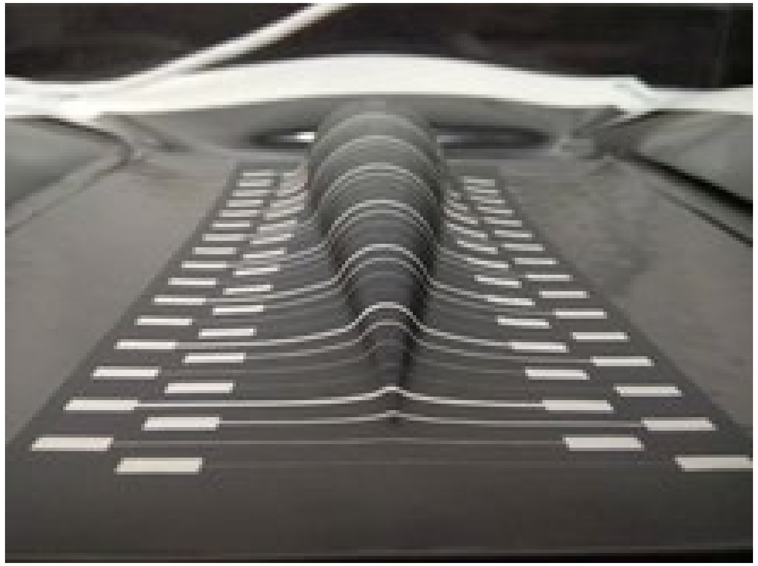
In-Mold Electronics for Automotive HMI Communications and Light-weighting

Topic:

7.6 Manufacturing of FHE-Enabled Automotive Components

Description:

Additive print process and component integration on thermo-formed substrates for creation of non-planar automotive surfaces used for HMI, sensing and communications. High-yield process recipes for printing conductive traces integration of SMT components into complex geometries.



Background and Related Work Performed:

- Significant body of prior work on the design of electronics for reliability and performance under sustained high temperature – high humidity – highG operation on the automotive platform.
- Leverage over 20-years of experience for automotive underhood electronics, OBD, and ADAS.
- Prior work on constitutive behavior characterization, modeling and life-prediction in automotive and defense applications.

Capabilities Sought in Potential Project Partners:

- Ink companies with materials compatible with thermo-forming processes
- Solder and ECA Companies with materials intended for IME
- Automotive Companies with interest in risk mitigation in use of technology

Contact: Pradeep Lall, lall@auburn.edu; (334)740-3424

TOPIC 7.7: WEARABLE HUMAN MONITORING / INTERFACE DEMONSTRATOR

$800,000 maximum Institute funds / Up to a 24-month duration

This topic seeks demonstration and evaluation of human monitoring systems enabled by state-of-the-art FHE components. Proposed manufacturing and system integration methods should be transferrable to volume manufacture with the development of scalable and cost-efficient manufacturing workflows. Proposers must identify why FHE is the preferred approach for their specific application(s) and why such a demonstrator advances the technology field. Projects should be careful not to duplicate prior efforts. Examples of possible demonstrators of interest include, but are not limited to:

a. Biopotential Electrodes with Improved Signal Quality for Dynamic Environments

b. Low-Cost Single Use Vital Sign Monitoring Devices

c. Textile-Integrated Electronics and Wearables for Operator Comfort / Human Robot Interfacing

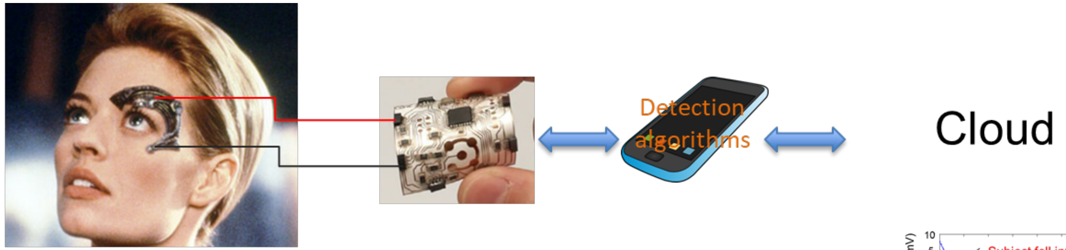
Wearable Human Attention Monitoring (Topic 7.7)

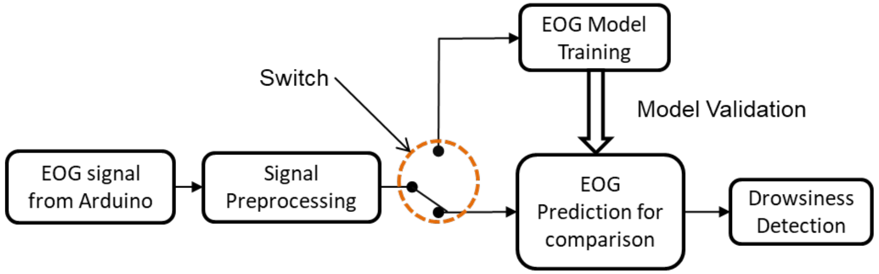
Objective: To develop and demonstrate a low-cost wearable human attention monitoring system using flexible hybrid electronics (FHE) design tools and manufacturing processes.

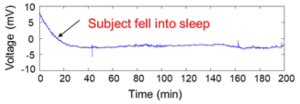
Background:

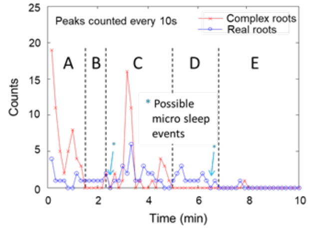
- Soldiers in combat rely on ability to instantly make the right decisions.
- Drowsy drivers causes 40,000 accident-related injuries and 1,500 death.
- Sleep deprivation decreases human performance.

Proposed approach/work performed:









Capabilities sought:

- Fabricating FHE circuits with battery and Bluetooth.

Contact:
Prof. Wei Li
Walker Department of Mechanical Engineering
The University of Texas at Austin
Email: weiwli@austin.utexas.edu
Phone: (512) 471-7174

TOPIC 7.8: OPEN TOPIC FOR "NEW PROJECT LEADS"

$350,000 maximum government funds / Up to a 12-month duration

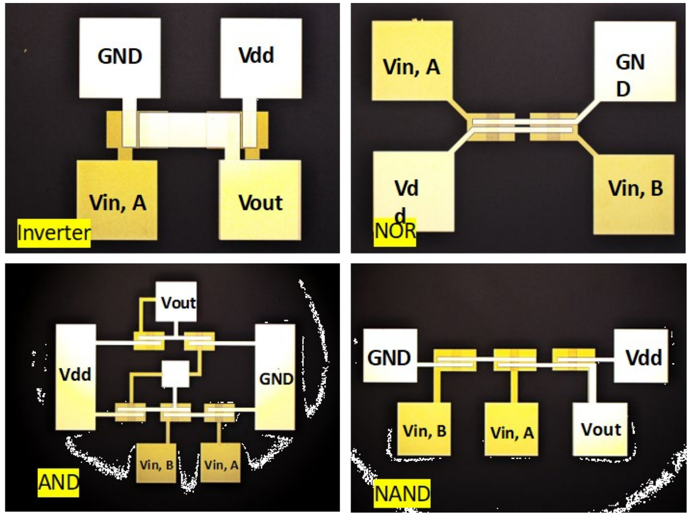
Delivering the NextFlex mission requires participation from across the U.S. FHE ecosystem. The purpose of this topic is to encourage participation from organizations that have not led a NextFlex PC project in the recent past.

Projects must align to the NextFlex Technical Working Group FHE Roadmaps and may address either manufacturing thrust or technology demonstrator topics. In the case of technology demonstrator development, the project should, at least in part, address the challenge of manufacturing such a demonstrator. For this open topic, proposals must clearly identify the technical working group(s) to which the project aligns, and the manufacturing capability gaps to be addressed.

Eligibility requirements: The lead proposer organization for this project must not have led a NextFlex project call project under either of the two most recent project calls (PC 5.0 and PC 6.0). As with all proposals, teaming is strongly encouraged; organizations that have led projects under PC 5.0 and/or PC 6.0 may be project partners, however at least 60% of the NextFlex funding for projects in this category must be allocated to organizations that meet this criterion (there is no restriction on allocation of cost share).

Multiple awards are anticipated under this topic subject to number and quality of submitted proposals.

Topic 7.8 Title : Print logic Gate Circuit Components



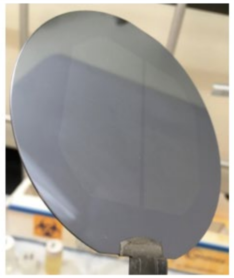
Printed logic gate electronics

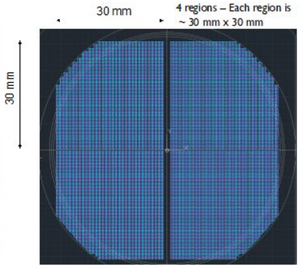
Proposed Concept

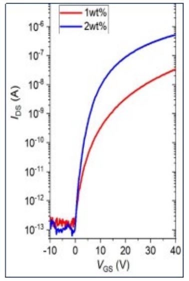
- Print logic gate such as inverters AND, NOR, NAND, for small scale integration (about 10 transistors) or for medium scale integration (between 10-100 transistors) by printing adders, decoders, counters, flip-flops and multiplexers.
- Materials should be able to be printed at the microscale with a minimum feature size between 2-5 micron.
- Use Northeastern's patented printing technology on flexible surfaces to shrink printed FHE boards by printing ultra fine resolutions logic gate circuit components.

Background on related work performed

- Printed logic gate circuit with fine resolution using a fully automated printing system with built-in alignment and registration capabilities.
- Realized high-throughput printing micro nanoelectronics.





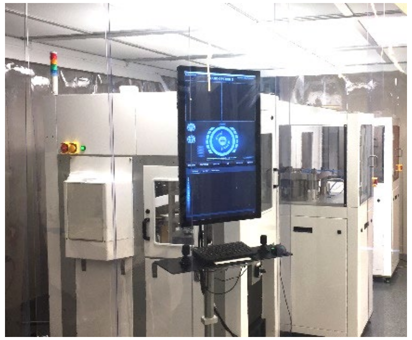


37,000 printed transistors with an on/off ratio higher than 10^6.

Capabilities sought in potential project partners

- Seeking partnership with large manufacturers and end users with use case for end applications.
- Seeking partners for circuit design, field testing and reliability studies.

Our work is conducted at the Northeastern's innovation campus and Kostas Research Center that includes an ITAR research facilities.



Nano & Micro Printing System

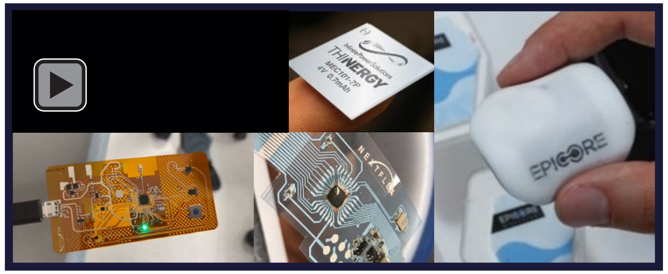
Ahmed Busnaina | a.busnaina@northeastern.edu | (617) 373-2992 |

FHE Safety for Use in High-Risk Environments

Topic: *Open Topic for "New Project Leads"*

Objective: Risk-reduce industry adoption of FHE technologies through enabling the **risk-assessment** and **safety certification** of FHE-enabled systems and components by including members of the safety certification community within the NextFlex ecosystem.

FHE Systems & Components



Workforce at High Risk

Partnership Opportunities

1) Sentinel is seeking **suppliers of FHE-enable demonstrator** and **component technologies** with a strong potential for providing value to physiological and environmental sensing in high-risk.
2) Sentinel is seeking partnerships with **safety testing organizations** with prior experience in supporting Intrinsic Safety (IS) or other safety certifications.

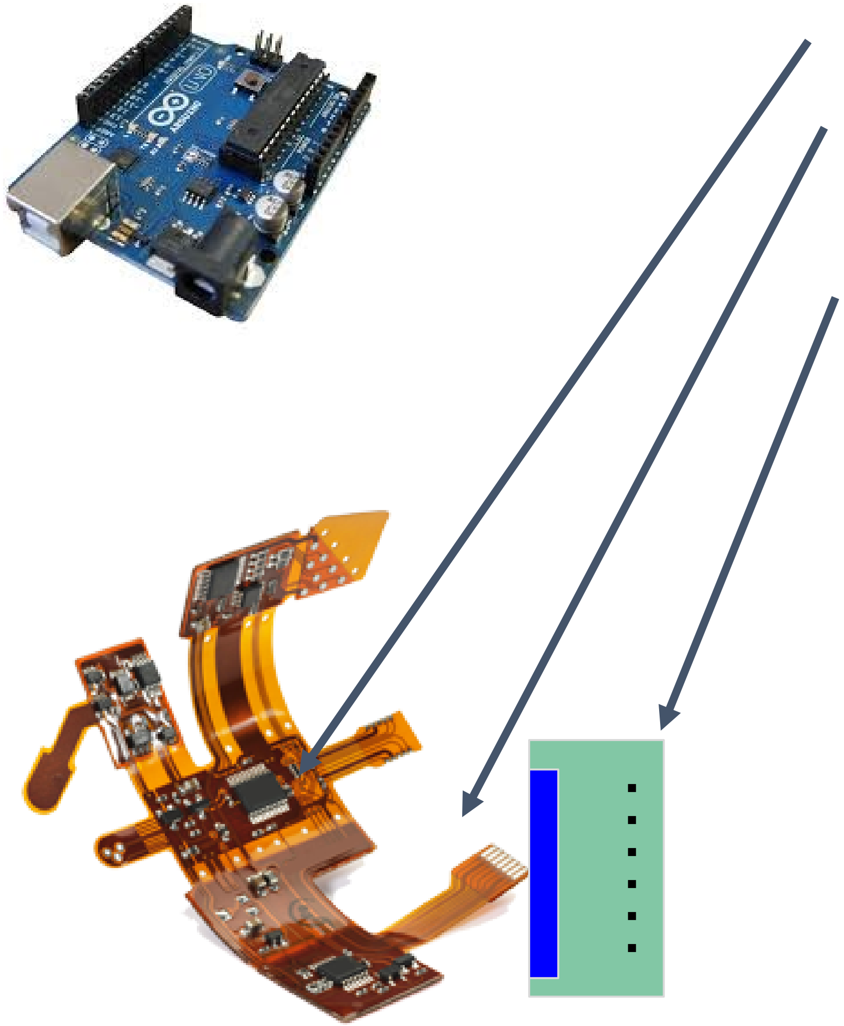
Scan Here to Learn More

SENTINEL
Health & Safety Made Personal™

www.sentinelofsafety.com

Jeremy Ward, Ph.D.
jeremy.ward@sentinelofsafety.com

FHE - Arduino Education Kit



- FHE with Arduino Atmel chip
- Flex connector for 14 GPIO and 6 Analog pins
- Hard PCB with Flex ribbon cable connector for GPIO and USB
  - Bread-Board connectable
- Educational Labs and Lessons
  - Complete Teacher ready Lesson Plans for:
    - 2 week, 4 week, 9 week lecture and labs to learn C++, Arduino, basic electronics and FHE
    - Capstone projects

Jim Burnham
jim.The.STEAM.Clown@gmail.com