Flexible Hybrid Electronics for Aerospace Applications


AFRL/RXAS
Materials & Manufacturing Directorate
Air Force Research Laboratory
Wright-Patterson AFB, OH 45433
AFRL: Turning Science Into Capability

Driven by Service Core Functions

Vectored by Air Force Strategy  +  S&T Vision/Horizons  +  Product Center Needs  +  MAJCOM Needs

6.1 Basic Research
6.2 Applied Research
6.3 Advanced Tech Demo

~ $5B
Science Knowledge

Technologies

Capability Concepts

Warfighter

Outputs:
New Technologies

25 Years

10 Years

5 Years

1 Year

Initial Operating Capability Timeline

Outputs:
Mature Technologies

Outputs:
Flagship Capability Concepts
What are Flexible Hybrid Electronics?

Convergence of Electronics Manufacturing Services & Roll-to-Roll / Digital Printing Industries

Printed Electronics

- Antennas
- Passive Elements

Placed Electronics

- Silicon ICs
- High Perf. Elements

- Heaters
- Batteries & Solar
- Sensors
How could Flexible Hybrid Electronics Impact the Air Force?

Man-Machine Interface
Airman performance limits capability in MANY military missions ....and new technologies are needed to sense, assess and augment the “Airman-in-the-Loop”

Embedded/Conformal Electronics for ISR/EW
Information and tracking in contested environments is foundational to decision making and force projection
- Communication (conformal apertures)
- Distributed electronics for feedback and structural health monitoring
- Reconfigurable Electronics

Integrated & Flexible Power
Energy limits operational capabilities and mission impact for unmanned vehicles and wearable electronics

Issues:
- Cost & Weight
- Scale-up
- Durability

Integrated Power harvesting, storage, and management

Survivable Electronics
Precision effects with smaller, low profile munitions pressing requirement for current and future platform effectiveness

- Robust electronics in extreme environments (shock, vibration, thermal)
## Technology Development Strategy

- Accelerate development and transition of FHE technologies to Air Force functional materials community
- Phased plan for FHE technology insertions

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**Critical Pre-requisites:**
- RPA Demo
- Composite Certification
- Hybrid-Materials Design
Direct-Write Conformal Antenna on MQ-9

Need

- Additional communications capabilities are required on the MQ-9.
- Conventional approaches to add antennas often requires new tooling (high cost, long lead time) and drilling of holes in the carbon fiber structure.
- Fuselage is crowded with apertures for communications, leading to co-site interference.

Technical Approach

- Retro-fit existing fleet with conformal antennas by simply replacing existing servo covers.
- Design and direct-write Cu antenna onto servo cover using plasma spray technique.
- Minimize co-site interference by installing onto unique locations of aircraft.

Phase I Results

- Indoor range data showed VSWR and directivity comparable with COTS components.
- Cu removal from part required a grinder.
- Significant directivity benefit in cross-polarization performance due to location...
Air Force Needs for Performance Monitoring

AF Mission Areas

- COTS products focus on primarily on motion and cardio-respiratory sensing, *with innovation/IP primarily targeting algorithm development*
- AF needs advanced biosignatures sensing for cognition, stress, fatigue, etc.
- Consumer products will not survive challenging AF environments
- AF needs unobtrusive devices with chemical and mechanical durability

Traditional electronic components and packaging will not meet Air Force requirements.
Flexible Materials & Devices
Research Leader: Dr. Benji Maruyama

Developing critical Materials & Processes to enable flexible hybrid electronic systems for airman performance monitoring

.........lightweight, flex/stretch, conformal, multifunctional, robust, autonomous

Novel materials
- Inherently strain-resilient
- Wafer thinning
- Liquid metals

Conformal & integrated printing approaches
- Rapid design cycle
- Enables retrofit
- Tailored materials and properties

Innovative packaging schemes
- Flex and performance
- Ensure survivability
Understanding Reliability and Physics of Failure for Wearable Devices

**AFRL program executed through NextFlex**

**Program Manager: Laura Sowards**
NextFlex: America’s Flexible Hybrid Electronics Manufacturing Institute

Established: August 2015
Lead: FlexTech Alliance
Hub location: San Jose, California
Members: 72 in 25 states
Federal Funding: $75M
Cost Share: > $95M
Government agencies engaged: 17

Focus: Combining the entrepreneurial & innovative culture of Silicon Valley with a national network of regional & technology nodes to commercialize FHE technology through manufacturing advancements in integrated printing & packaging, system design tools, materials scale-up, thinned device processing, and reliability testing & modeling.

Catalyzing a robust and innovative manufacturing ecosystem at the intersection of the electronics and high performance printing industries.