

# Sensors and Instrumentation Webcast

Curtis Hill | On-Demand Manufacturing of Electronics (ODME) | 01.18.22



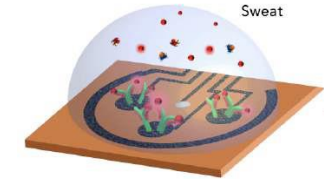
# In-Space Manufacturing (ISM) Overview

## Project Description

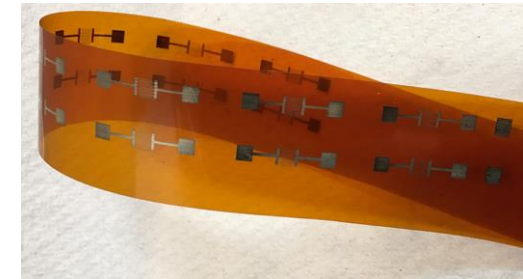
- The 3D Print Tech Demo launched on SpaceX-4 (9/21/14) – In-Space Manufacturing (ISM) was “grown” from that tech demo.
- The ISM portfolio provides a solution for sustainable, flexible missions through on-demand fabrication, replacement, and recycling capabilities.
- The ISM portfolio includes three GCD projects: (1) On-Demand Manufacturing of Metals (ODMM); (2) On-Demand Manufacturing of Electronic components (ODME); and (3) Recycling and Reuse (RnR).
- ISM also includes a demonstration of 3D printing with lunar regolith simulant, funded by HEOMD AES.

## Customers

- Game Changing Development (GCD)
- Advanced Exploration Systems (AES)
- ISS, industry, and academic partners



CalTech MIP Cortisol Sensor



Printed FHE CO<sub>2</sub> sensor



TechShot FabLab Multimaterial 3D printer for ISS Demo

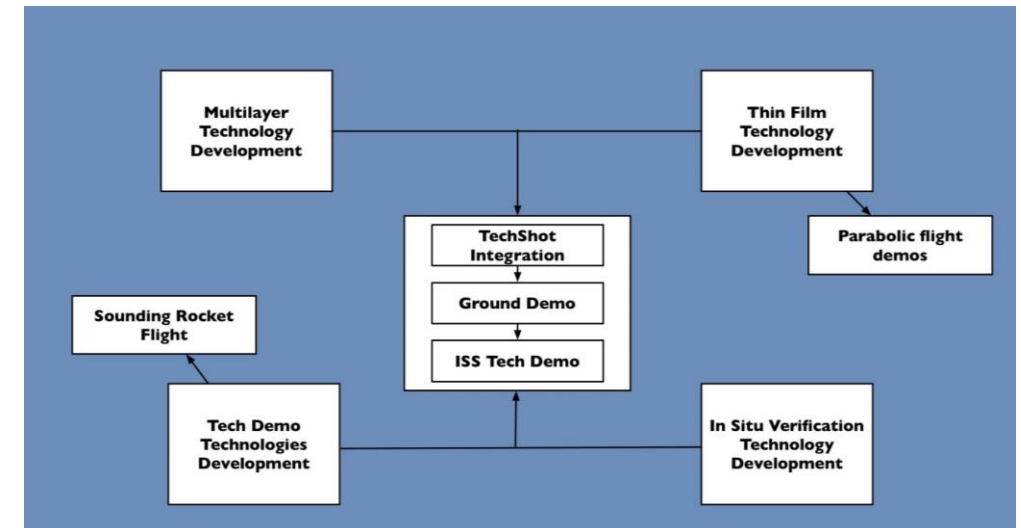


AstroSense wireless wearable biosensor device

ISM provides a meaningful capability for on-demand manufacturing during exploration missions. The project will continue to test manufacturing technologies on the ISS and influence future exploration systems design.

# On-Demand Manufacturing of Electronics (ODME) Overview

- **Technology Product Capability**
  - On-Demand Manufacturing of Electronics (ODME) has the critical function of building crew and structural monitoring systems and sensors in orbit.
- **Technical Capabilities**
  - Development of Multilayer Technology for Flexible Electronics
  - Development of Thin Film Technology for Microgravity
  - Development of In-Situ Verification Technology
  - Development of ODME Flight Demo for ISS
- **Exploration & Science Applicability**
  - Applicable to current ISS operations
  - Applicable to Artemis II, Lunar Surface Habitat
  - Applicable to MTM and future missions



Overview of ODME Technical Approach

# On-Demand Manufacturing of Electronics (ODME) Overview



## On-Demand Printed Electronics Capability Development:

### • Development of Thin Film Deposition Capability in Microgravity

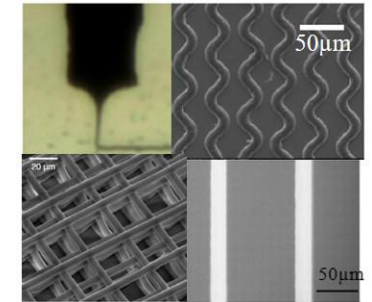
- The objective of the Thin Film Deposition Technology development is to evaluate alternate thin film deposition systems for the best system to print printed electronics and sensors in microgravity.
- A threshold value of a 300 microns resolution (minimum printable feature size) was chosen because this is the solution with the minimum complexity required to fabricate electronic devices in microgravity. The Project Goal is to demonstrate fabrication processes with 100 micron or better resolution. Current State-of-the-Art (SOA) of printed resolution of electronic materials is between 30 and 50 microns for analogous ground-based processes.

### • Development of Multilayer Technology for Microgravity

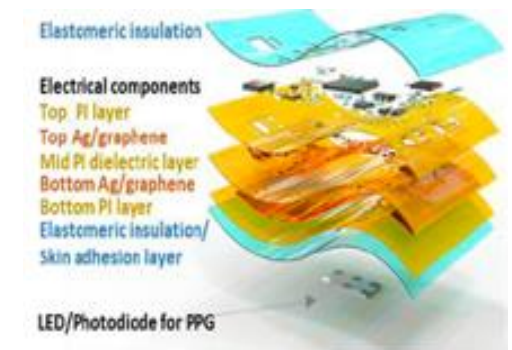
- The objective of the Multilayer Technology development is to develop materials, processes, and equipment modifications as necessary for the stacking of circuitry layers of printed electronics. This will enable a much wider range of potential applications and printed electronic capability.
- A threshold fabrication ability of a single layer printed “board” was chosen because this is the solution with the minimum complexity required to fabricate electronic devices in microgravity. The Project Goal is to demonstrate fabrication of multi-layered electronic devices in microgravity.

### • Development of Validation and Verification In-Situ Capability for Flight Demo

- The objective of the Validation & Verification development is to develop test procedures, software, and hardware to effectively test function and operation of the ODME printed flight demo on ISS.
- The development of In-situ Verification is a two-year project to develop and evaluate optimum methods, hardware, and integration to the 3D printer operation, in order to effectively validate the operation of flexible hybrid electronics sensors and devices.



Electrohydrodynamic inkjet deposition for microgravity



Multilayer thin film printed device work with Georgia Tech

# On-Demand Manufacturing of Electronics (ODME) Overview



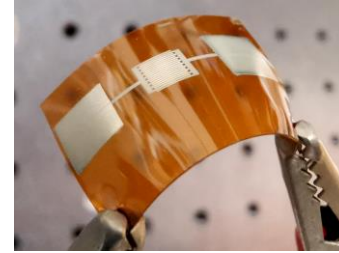
## On-demand printed electronics capability development:

### • Flight Demo Technologies Development -

- The objective of Flight Demo technologies development is to develop the necessary technologies for a successful demonstration of printed electronics and sensors in microgravity. These technologies includes sensor development, development of post-processing technologies, wireless communications, energy and power for self-powered sensor operation, and in situ verification of the completed devices. This is our core ODME development integrating all the other development efforts.
- The flight demo device is a flexible wearable multi-sensor device being developed in a collaboration with NextFlex and multiple NASA Centers as the AstroSense wearable device.
- The development of Flight Technologies includes the multi-Center and outside collaborators development of associated technologies for the device, including:
  - Development of multiple environmental and biosensor technologies
  - Development of on-demand printed power harvesting technologies
  - Development of on-demand printed energy storage technologies
  - Development of laser sintering post-processing capability
  - Development of next-generation 3D printing hardware for multi-material high precision deposition of nanomaterials for electronics and sensors.



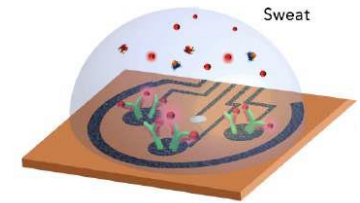
AstroSense wireless wearable sensor (cortisol, temp, humidity)



Printed CO<sub>2</sub> sensor for Crew Health Monitoring



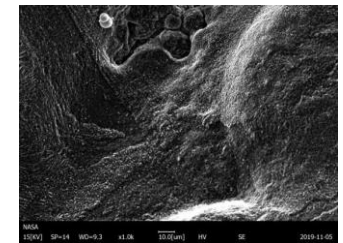
Flexible, printed supercapacitor for energy storage



Printed cortisol biosensor for monitoring astronaut stress



nScript Next-Generation Deposition Heads



Laser sintered Ti64

# ODME Development



## Flight Demo Technologies Development

- Re-started NextFlex project (AstroSense) for development of Crew Health Wearable biosensor device. FY21 development of Sensing Potentiostat. FY22 delivery of Beta Wearable Sensor Devices.
- Flight Demo Technology Projects:
  - **Internal NASA**
    - » **MSFC:**
      - Development of post-processing methods (laser sintering & photonic sintering)
      - Materials development of electronic inks for collaboration support
      - Development of micro-milling processes for advanced coatings & energy storage devices
      - Testing & verification of sensors, materials, & processes
      - Development of power-harvesting & energy storage technologies
    - » **ARC**
      - Aptamer-based cortisol sensor for incorporation into AstroSense
      - Printed colorimetric CO<sub>2</sub> sensor
      - On-demand printed supercapacitor
      - On-demand printed bone density sensor

# ODME Development



## Flight Demo Technology Projects:

- **Internal NASA**

- » **GSFC:**

- Sounding rocket test flight coordination
    - Development of printed superconducting devices
    - Test & characterization of flexible batteries for printed electronics

- » **JSC:**

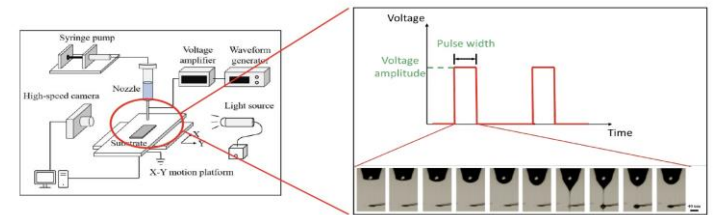
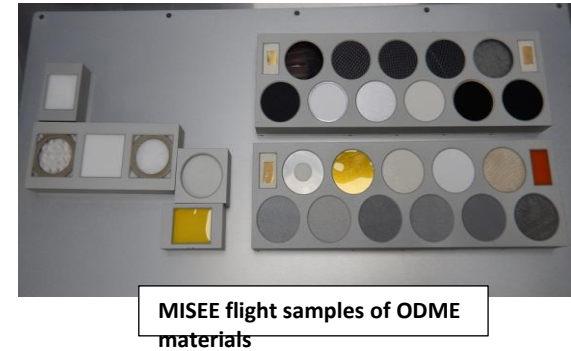
- Development of HYDRA next-generation RFID antenna network
    - Development of RFID sensors and sensing technology

# ODME Flight Demonstrations



## On-demand printed electronics capability development:

- **Flight Testing Verification -**
  - **Parabolic flights of Thin Film Deposition development November - December 2021**
    - **Space Foundry Inc.** – demonstration of Plasma Jet Deposition
    - **Iowa State University** – demonstration of Electrohydrodynamic Inkjet Deposition
  - **Sounding Rocket flight test** of printed electronics and printed sensors planned in late FY 2022. Collaborative project with NASA GSFC and NASA Wallops with GSFC ODME team as lead.
- **Materials International Space Station Experiment (MISEE) - Testing of ODME materials on ISS for radiation and atomic oxygen**



Iowa State Electrohydrodynamic Inkjet



Space Foundry Plasma Jet



Sounding Rocket Flight Test

# ODME Mission Infusion & Partnerships

## Materials

### NASA Centers

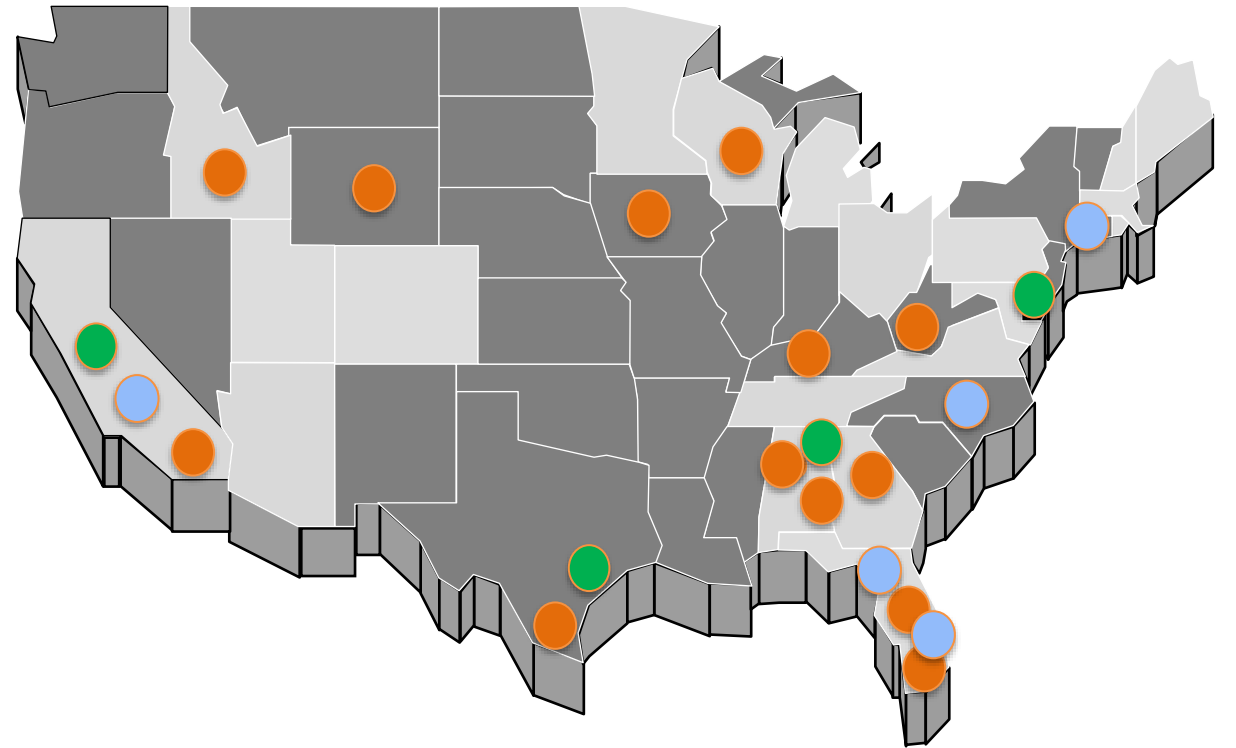
- GSFC
- MSFC
- ARC
- JSC

### University Collaborations

- University of Alabama Huntsville (UAH)
- Auburn University
- Boise State
- Georgia Tech
- CalTech
- Iowa State University (ISU)
- University of Miami
- Florida A&M University
- West Virginia University
- Youngstown University
- University of Texas El Paso (UTEP)
- University of Louisville
- University of Wyoming

### Private Companies

- NextFlex
- nScript
- Multi3D
- LambdaVision
- Redwire/Made in Space



Collaborative multidisciplinary partnerships to leverage fiscal resources, ideas, knowledge & expertise.

# Summary



- **University Project Collaborations started in FY21**
  - Started 19 new projects with 12 different universities
- **NASA@work funded projects**
  - Started 2 new research projects at 2 NASA Centers
- **Interns**
  - OMDE mentored a total of 6 interns this year
  - ODME served as Research Collaborator for 2 new NSTGRO Graduate Fellowship Researchers, from two different universities.
- **Publications and EPO**
  - Published 11 new research papers in collaboration with four different universities
  - Presented ODME project research at 3 different conferences
  - Presented to 4 student groups from elementary age to university graduate students

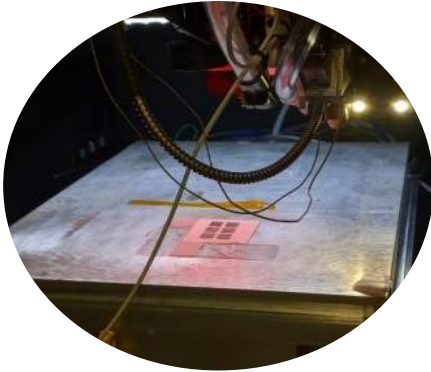
# Summary



**Thank you for attending the webcast today.**

**Questions?**

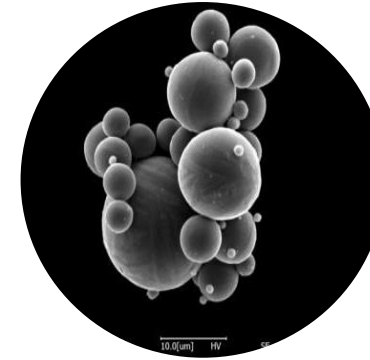
# Cover Slide Annotate Images



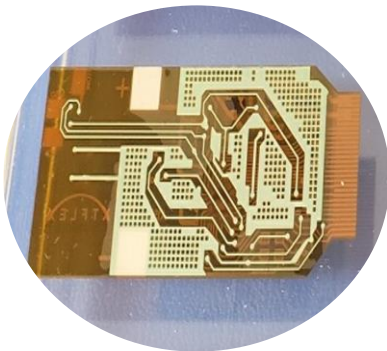
Laser Sintering



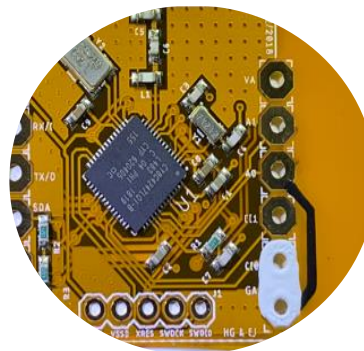
Fabrication Laboratory (FabLab)



Titanium (Ti-64) molecule



Multilayer flexible electronic device



Multilayer flexible electronic device



AstroSense wireless wearable sensor