THE ADDITIVE MANUFACTURING OF CONFORMAL ELECTROMAGNETIC DEVICES ON COMPOSITE SUBSTRATES

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Advanced Manufacturing Technology Center

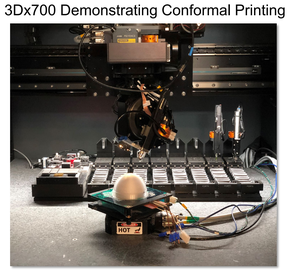
Research to optimally design and develop functional RF devices, systems, and structures that cannot be fully realized using conventional manufacturing but can be using AM technologies such as multi-material and conformal AM

Advanced Manufacturing Technology Center

Conformal Printing

- Enables direct write techniques to be utilized on extreme topologies such as doubly curved surfaces
- Realized using 6-axis machine (nScrypt 3Dx-700)
- Offers the ability to produce electromagnetic devices on arbitrary surfaces which may feature multiple layers

3Dx700 Demonstrating Conformal Printing

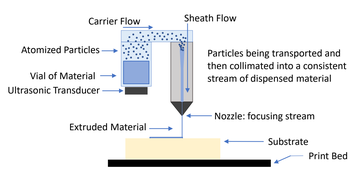


3Dn-300 Hybrid AM Machine

Direct Write Methods Explored

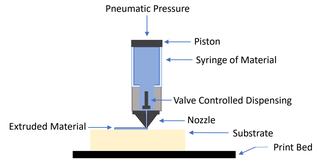
Aerosol Jetting Head

(Integrated Deposition Systems)



Micro Dispense Head

(nScyrpt SmartPump™)



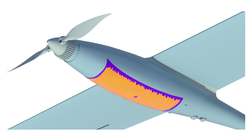
Conformal Holographic Antenna

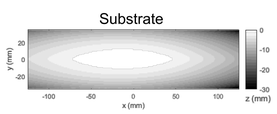
Goals

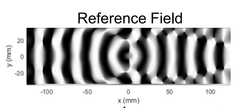
- Develop direct write methods to physically realize a conformal Voronoi Metasurface
- Improve upon current manufacturing methods that are tedious and time consuming
- Demonstrate feasibility of methods developed
- Verify the engineered electromagnetic properties through physical characterization

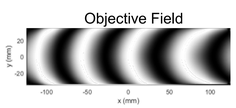
Antenna Design

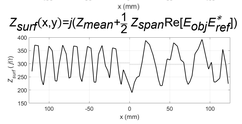
- Leaky wave antenna design at Australia's Defence and Technology(DST) Group
- 30 degrees forward directional pencil beam operating at 10GHz
- Substrate designed to conformally adhere to UAS

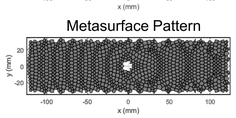






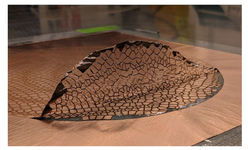






Current Manufacturing Method

- Laser profile etching of copper foil negative coupled with hand removal, placement and alignment
- Time consuming process
- Two-dimensional plane cannot map to extreme arbitrarily doubly curved surfaces without deformation



Developed Method of Aerosol Jetting and Electroless Platting

- Aerosol jetting head coupled with 6-Axis Nscyrpt to conformally pattern substrates with nano particle conductive ink (UT DOTS)
- Post processing electroless plating step employed to improve RF conductivity of patches and realize desired RF properties

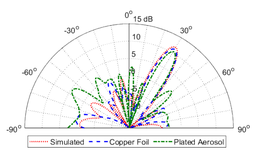
Printing Holographic Antenna

IDS Fixed to Rotary Stages

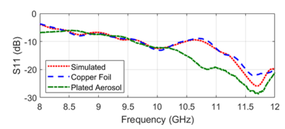
Measurement Results

- Sufficient gain patterns realized using platted aerosol method
- Reduction in manufacturing time realized

Gain at 10GHz



S11 Demonstrating Resonance



Bulk RF Conductivity Characterization

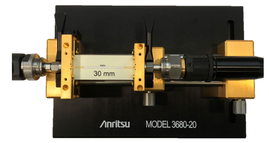
Goals

- Develop a test method for consistent bulk conductivity characterization of direct write inks up to 26.5 GHz
- Print microstrip with nScrypt micro dispensing or IDS aerosol jetting systems
- Measure microstrip with the Anritsu UTF Test Fixture over 2.0 GHz to 26.5 GHz band
- Characterize print thickness, surface roughness and resolution with Keyence Laser Microscope

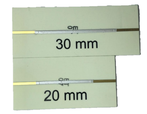
Test Setup

- Two Custom PCBs were designed to maximize repeatability and accuracy of measurements
- Multiple inks were deposited then characterized using the Anritsu test bed and a network analyzer

Anritsu Test Bed



Custom PCB with CB0228 Deposited



Characterization Results

- A copper baseline microstrip was used to confirm the accuracy of the system
- The resulting conductivities can be used to determine which inks are best suited for a specific RF application

Bulk Conductivities of AM Inks