

High-Precision Electrochemical Additive Manufacturing (ECAM) of an Eight-Radial-Element 3D-Printed Ultrawideband High-Gain Radial Vivaldi Array Antenna (RAVA)

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This paper presents a novel electrochemical additive manufacturing (ECAM) approach for fabricating the proposed 3D-printed metal Radial Vivaldi Array Antenna (RAVA) (K. Kakaraparty and I. Mahbub, “Highly compact and cost-efficient metal-coated UWB 3D Vivaldi radial array for RADAR applications,” in *Proc. International Symposium on Phased-Array System and Technology*, 2024). This novel ECAM process offers a transformative method for fabricating high-precision, complex 3D structures, surpassing traditional Additive Manufacturing (AM) and CNC Milling. Its key innovation is a micro-electrode array printhead with programmable pixels sized in tens of microns. ECAM uses a water-based feedstock of inexpensive metal salts, with metal ions supplied by an electroplating solution circulating between the cathode (build plate) and anode (printhead) during printing. This tight feedback loop, enabled by real-time adjustments to print parameters, actively controls build progress and ensures part quality. To precisely deposit metal onto the build plate at the intended areas, an electric current is generated. Proprietary print algorithms use the electrodes to monitor the printing process in situ, determining when copper has been coated as desired. ECAM ensures micro-scale fabrication, aligning RAVA element dimensions with design specifications for resonance and impedance matching at high frequencies Fig. 1. Additionally, smooth, uniform surfaces ensure consistent current flow, essential for the multiport RAVA's radiation pattern and gain, while preventing phase shifts. The smooth surface minimizes scattering and resistive losses at the high frequencies where the RAVA array operates, highlighting the significance of the novel ECAM process for mm-Wave 3D-printed antennas and RF interconnects. The ECAM RAVA's performance will be evaluated by comparing its measurement results with those of the previously proposed RAVA, metalized via electrodeposition after 3D printing with Acrylonitrile Butadiene Styrene (ABS).

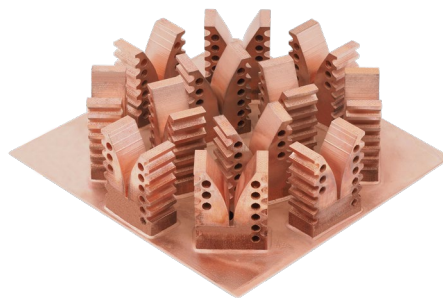


Figure 1. A prototype of 3D printed radial Vivaldi array antenna using electrochemical additive manufacturing method.