Additive Manufacturing of Electronics and Ceramics

L. Lyle, J. Fox, L. Peeke, D. Erdely, R. Lavelle, I. Adu, D. Snyder, M. Krohn

Abstract: Additive manufacturing of electronics and ceramics has been gaining interest over the last decade because of its capability to rapidly prototype devices with complex geometries, reduce manufacturing costs, and directly produce components at the point of need. These unique advantages can overcome issues facing traditional integrated circuit technology and ceramics processing. Specifically, additive manufacturing of electronics enables printed circuits on conformal structures and the realization of flexible/stretchable electronics and additive manufacturing of ceramics expands the landscape of possibility of ceramic green body forming with capability for unique ceramic structure and microstructure engineering. Further, fabrication of multi-material packages enables the realization of fully-printable electronic systems and the fabrication of compositionally graded ceramic components. Development of "factory-in-a-box" technologies for rapid fabrication of electronics and ceramics on suitable substrates has the potential to reduce overall manufacturing labor with touch time reduction and enable on-demand fabrication at the point-of-need.

The work presented showcases the ongoing additive manufacturing of electronics and ceramics efforts occurring at the Electronics and Materials Devices Department (EMDD) of the Applied Research Lab (ARL) at Penn State. The work showcased here focuses on development of an S-band antennas out of graphene-based composite conductors and standard silver metallic inks, process optimization of constant-feedrate, direct extrusion printing utilizing a load cell, along with progress in ceramic element direct-writing highlighting scalability, complex design toolpathing, thermal processing and characterization of ceramics for optical applications.