Electrical Characterization of Traditional and Aerosol Inkjet Printed Conductors under Tensile and Strain

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Abstract

Emerging additive manufacturing fabrication methods offer promising alternatives to traditional rigid manufacturing tooling and processing for the nascent field of flexible hybrid electronics (FHE) (Nathan et al., Proc. IEEE 100, 2012). Additive manufacturing techniques allow for rapid design prototyping (Vaezi et al., Int J Adv Manuf Tech, 2013) and, more recently, incorporation of novel materials into complex device geometries (Kim et al., ACS Appl. Mater. Interfaces, 2013; Folgar et al., Mater. Lett.,2011) . One specific additive manufacturing technique is aerosol inkjet printing, which can precisely deposit any aerosolizable bulk material onto a variety of surfaces – curved, rigid, flexible, nonuniform, elastic, and hybrid (Adams et al., Electron. Lett, 2015). We have investigated the properties of aerosol inkjet printed conductors, specifically silver micro flake and CNT inks, on PDMS and compared them to more conventional sputtered copper and evaporated silver traces.

There are no specific IPC, ASTM or MIL standard characterization techniques for flexible and stretchable devices (DoD FOA-RQKM-2015-0014), though some initial work has been done to adapt these standards to flexible products (IPC-TM-650, # 2.4.3). We have developed a material-agnostic set of mechanical tests for FHE that are characterized by performance in response to tensile and flexural strains. These metrics apply the critical aspects of industry standards for adhesion (IPC-TM-650, #2.4.1.6) and electrical performance (ASTM F1711-96) of conventional electronics to soft dielectric conductor pairings. The electrical properties and interfacial adhesions of sputtered and evaporated metals on PDMS have been characterized under single and cyclic flexural and tensile strains up to 50% and compared to the performance of aerosol inkjet printed materials. Determination of the relative elasticities and critical strain limits of the various conductors will qualify the suitability of traditional and novel materials and methods to FHE platforms, such as implantable biosensors, conformal RF communication systems, wearable electronic devices, zero-stress chip packaging, and more.