Paper ID: 62568
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advancements in Materials Applications and Rapid Prototyping (5)

Author: Mr. Ved Vakharia
University of California, San Diego, United States, ved.vakharia@gmail.com

Mr. Michael Halbig
NASA Glenn Research Center, United States, michael.c.halbig@nasa.gov
Dr. Mrityunjay Singh
Ohio Aerospace Institute, United States, mrityunjay.singh-1@nasa.gov

3-D PRINTING AND CHARACTERIZATION OF METAL POLYMER (PLA) COMPOSITES FOR MULTI-FUNCTIONAL APPLICATIONS

Abstract

Commercial availability of affordable desktop 3-D printers have introduced additive manufacturing to all disciplines of science and engineering. With innovation in 3-D printing technology, new filament materials, specifically multifunctional metal reinforced polymers are being offered by material vendors. However, systematic studies are necessary to understand the effects of filament composition, type and volume of metal reinforcements, and print parameters on microstructure and mechanical behavior of 3-D printed materials. This study investigates the potential of four type of metallic reinforcements in 3-D printed PLA material systems: bronze, copper, magnetic iron, and stainless steel. Multiple methods were used to determine the densities of the material systems. Thermogravimetric Analysis (TGA) was used to quantify the metal wt% and vol%, and cross-sectional metal area% was observed through optical microscopy in conjunction with analysis using ImageJ (open source image processing program designed for scientific multidimensional images). Comparisons are made between polymer microstructures before and after printing to show the beneficial effects of the printing process on the strength of the metal-polymer interface adhesion. Tensile coupons of all material systems were prepared according to ASTM D 638. Tensile response as a function of metal vol% and print layer height was studied. PLA material systems were found to perform consistently regardless of print layer height, unlike the other common 3D printed material ABS. Tensile tests show that PLA filaments containing approximately 36 vol% of bronze or copper significantly reduce mechanical properties and they therefore should be used for lower stress multi-functional applications. The mechanical response of PLA with 12 and 18 vol% of magnetic iron and stainless steel, respectively, behaves similarly to that of pure PLA with a slight decrease of ultimate tensile strength showing its potential as a PLA replacement where comparable strength is needed with the addition of multi-functionality. These results demonstrate, for the first time, the potential for tailoring the concentration of these metal reinforcements in order to provide multi-functionality without sacrificing mechanical properties.