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Multifunctional Metal Matrix Composites with Embedded Printed Electrical Materials Fabricated by Ultrasonic Additive Manufacturing

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Abstract

This work proposes a new method for the fabrication of Multifunctional Metal Matrix Composite (MMC) structures featuring embedded printed electrical materials through Ultrasonic Additive Manufacturing (UAM). Printed electrical circuitries combining conductive and insulating materials were directly embedded within the interlaminar region of UAM aluminium matrices to realise previously unachievable multifunctional composites. A specific surface flattening process was developed to eliminate the risk of short circuiting between the metal matrices and printed conductors, and simultaneously reduce the total thickness of the printed circuitry. This acted to improve the integrity of the UAM MMC's and their resultant mechanical strength. The functionality of embedded printed circuitries was examined via four-point probe measurement. DualBeam Scanning Electron Microscopy (SEM) and Focused Ion Beam (FIB) milling were used to investigate the microstructures of conductive materials to characterize the effect of UAM embedding energy whilst peel testing was used to quantify mechanical strength of MMC structures in combination with optical microscopy. Through this process, fully functioning MMC structures featuring embedded insulating and conductive materials were realised whilst still maintaining high peel resistances of ca. 70 N and linear weld densities of ca. 90%.

Keywords: Ultrasonic additive manufacturing; Metal matrix composites (MMCs); 3D Printing; Embedded electrical circuitry; Mechanical testing; Electron microscopy;

1. **Introduction**

Multifunctional Additive Manufacturing (MAM) is now becoming an important research area in the Additive Manufacturing (AM)/3D Printing (3DP) arena. Unlike traditional AM processes, which mostly deal with mono-functional homogenous structures, MAM combines different types of AM processes to enable the fabrication of novel structures capable of providing high end-use

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