Aerospace Engineering Thesis Defense

Physical Modeling and Simulation of Polymeric Structures with Metallic Material Printed by Electrically Assisted Vat hotopolymerization for Property Enhancements

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Abstract

Applications like integrated circuits, microelectromechanical devices, antennas, sensors, actuators, and metamaterials benefit from heterogeneous material systems made of metallic structures and polymer matrixes. Due to their distinctive shells made of metal and polymer, scaly-foot snails, which are found in the deep ocean, exhibit high strength and temperature resistance. Recent metal deposition fabrication techniques have been used to create a variety of multi-material structures. However, using these complex hybrid processes, it is difficult to build complex 3D structures of heterogeneous material with improved properties, high resolution, and time efficiency. The use of electrical field-assisted heterogeneous material printing (EFA-HMP) technology has shown potential in fabricating metal-composite materials with improved mechanical properties and controlled microstructures. The technology is an advanced form of 3D printing that allows for printing multiple materials with different properties in a single print. This allows for the creation of complex and functional structures that are not possible with traditional 3D printing methods. The development of a photocurable printing solution was carried out that can serve as an electrolyte for charge transfer and further research into the printing solution's curing properties was conducted. A fundamental understanding of the formation mechanism of metallic structures on the polymer matrix was investigated through physics-based multiscale modeling and simulations. The relationship between the metallic structure's morphology, the printing solution's properties, and the printing process parameters was discovered.

The thesis aims to investigate the microstructures and electrical properties of metal-composite materials fabricated using EFA-HMP technology and to evaluate the correlation between them. Several samples of metal-composite materials with different microstructures will be fabricated using EFA-HMP technology to accomplish this. The results of this study will provide a better understanding of the relationship between the microstructures and properties of metal-composite materials fabricated using EFA-HMP technology and contribute to the development of new and improved materials in various fields of application. Furthermore, this research will also shed light on the advantages and limitations of EFA-HMP technology in fabricating metal-composite materials and study the correlation between the microstructures and mechanical properties.

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