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Editorial

3D Printing Functionality: Materials, Sensors, Electromagnetics

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Additive manufacturing has enabled multifunctional structures, sensors, devices, and platforms to be used in a multitude of fields. However, as the number of advanced manufacturing applications increases, so do the requirements for accurate design tolerance and as-printed part performance. As such, this Special Issue addresses some of the primary challenges faced when creating functional 3D-printed parts. Specifically, these articles focus on leveraging process variability and printing inconsistency for improved part dimensionality and performance. These improvements can be achieved through optimization, automation, statistical analysis, and reliability testing for a variety of printing methods.

In the article, entitled "Overcoming Variability in Printed RF: A Statistical Method to Designing for Unpredictable Dimensionality," the authors utilize large sample sets, modeling, and statistical analysis to demonstrate that one can leverage the inherent variability in printed devices to create functional RF structures to meet any design metric [1]. This research demonstrates how the variability of a printing tool will non-linearly affect the RF performance of an X-band patch antenna. By integrating RF design with modeling and print variability, the authors demonstrate the ability to improve the S-parameters of large-batch printed antennas by up to 7 dB. The methods provided in this research have direct applicability to image classification in machine learning to provide predictive RF performance [1].

Similarly, the study entitled "An Automated Open-Source Approach for Debinding Simulation in Metal Extrusion Additive Manufacturing," utilizes finite element analysis in order to determine if a printed part will meet critical stress limits before any printing occurs [2]. This analysis takes into consideration orientation-based, sinter-induced shrinkage during the debinding process of metal extrusion additive manufacturing. The authors utilized open-source software to determine the optimal part orientation during debinding in an automated simulation framework [2].

As fabrication methods change, so do the requirements for the successful design of parts. In "A Shape Optimization Method for Part Design Derived from the Buildability Restrictions of the Directed Energy Deposition Additive Manufacturing Process," the authors introduce topology optimization to improve the additive manufacturability of parts using directed energy deposition [3]. The author's framework analyzes the internal stresses within a build volume to determine optimal build orientation. The result is a top-down method to delimitate the morphing of a printed part, while also screening the percentage of design elements that can be optimized before printing occurs [3].

In "Interconnections for Additively Manufactured Hybridized Printed Electronics in Harsh Environments," the authors begin to explore the consequences of integrating printed systems with standard/ridged or hybrid systems [4]. This study focuses on material pairings in order to create resilient connections with respect to sudden shocks, drops, or crashes. The authors explore multiple material systems and compare material selections to survivability for environments in which traditional 3D-printed electronics are unsuitable [4].

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