

Editorial

Recent Advances in 3D Printing and Additive Manufacturing Technology

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1. Introduction

Additive manufacturing (AM) or 3D printing has played a critical role in Industry 4.0 due to its rapid development over the last few decades [1,2]. Using the layer-by-layer approach, AM technologies can successfully fabricate structures with unique shapes that might be difficult to achieve using conventional methods [3]. In fact, AM technologies have revolutionized the design, manufacture, and distribution of products [4–6]. More importantly, AM with localized and on-demand production, faster lead times, and high cost-saving rates has offered several advantages to address the increased import costs and supply chain disruptions in the recent tariff-driven economy of many countries [7,8]. The current breakthroughs in material science, hardware and system development, and artificial intelligence (AI) have allowed AM to reshape various industry sectors, from automotive and aerospace to consumer products and healthcare [9–13]. Motivated by the rapid evolution of AM, this Special Issue of “Recent Advances in 3D Printing and Additive Manufacturing Technology” is introduced to present the latest research on cutting-edge developments in this dynamic field.

2. Critical Studies on AM and 3D Printing

Recently, many research studies have explored the novel applications and breakthroughs of 3D printing for medical applications [14,15]. In fact, the advantages of AM have enabled the production of medical devices with better customization, lower production times, and have offered new advanced solutions for drug delivery [16,17]. For example, Kyung-Eun Min et al. addressed the issue of low degradation rates and poor mechanical properties of biomaterials used in bone tissue engineering [18]. In their research work, they explored the use of dimethyl sulfone (DMSO₂) as an additive to enhance the performance of a blend made from polycaprolactone (PCL) and polylactic acid (PLA) for regenerating or replacing damaged bone tissues. The results showed that the yield strength and Young’s modulus of the PLA/PCL/DMSO₂ composites were significantly higher than those of pure PLA, pure PCL, and PLA/PCL blends. More importantly, it was found that the hydrophilicity of the composites increased with a higher DMSO₂ content, resulting in better cell adhesion.

Among AM methods, material extrusion (MEX) 3D printing is one of the most widely used processes with many practical applications owing to its ease of handling, cost-efficiency, and ability to fabricate complex structures [19,20]. In a recent study conducted by Dariusz Pyka et al., the mechanical properties and biocompatibility of eight commercially available filaments were investigated for Fused Filament Fabrication (FFF) 3D printing [21]. The results showed that PETG Carbon and PA+15CF possessed outstanding



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tensile and flexural strengths, and all materials except for Fiber-Flex 40D Fiberology were non-cytotoxic, indicating their potential in biomedical applications. This comprehensive study offers a better understanding of the mechanical properties of thermoplastic feedstock materials and their suitability for biomedical applications.

Similar to FFF 3D printing, Direct Ink Writing (DIW) is also a widely used material extrusion 3D printing method to process viscoelastic paste (also referred to as “ink”) [22,23]. In recent research work conducted by Changuk Ji et al., a pneumatic pressure syringe-type dispensing system integrated with a food-grade printer was developed to hygienically dispense viscous food materials in small quantities on demand [24]. It was found that the selected nozzle exhibited uniform flow distribution and discharge behavior at a viscosity of 30,000 cps and a controlled inflow rate. Among four different nozzle toolpath strategies used to minimize nozzle movement, the 16-step path design was the most effective with no tailing observed when printing under conditions of 0.2 MPa pressure and a −15.4 kPa vacuum.

The integration of AI into AM has gained attention from both industry and academia due to its potential to make manufacturing processes smarter, more autonomous, and highly efficient [25]. With the capabilities of data analysis and process optimization, AI can enhance design efficiency, accelerate material development, predict and optimize printing processes, and ensure the quality of AM-produced outputs [26,27]. The rapid integration of AI into AM motivated Osman Ulkir et al. to conduct their research study on the prediction of AM parameters using machine learning (ML) algorithms [28]. In their study, five ML algorithms, including support vector machine, Gaussian process regression, artificial neural network, decision tree regression, and random forest regression (RFR) techniques, were employed to predict the optimal raster angle for FFF printing. The results suggested that RFR outperformed the other models and effectively predicted the optimal raster angles for any geometry in FFF printing.

Although copper possesses high value for various applications such as thermal management, electronics, and aerospace, it is challenging to process this material using AM due to its high thermal and electrical conductivity [29,30]. Together with its high oxidation susceptibility, this method is unable to consistently melt copper through common AM methods such as laser powder bed fusion or Wire Arc Additive Manufacturing (WAAM) owing to the high reflectivity of copper to laser energy [31–33]. Therefore, many efforts have been made to optimize the printing parameters to achieve high-quality 3D-printed copper parts. In their paper “Study of Various Process Parameters on Bead Penetration and Porosity in Wire Arc Additive Manufacturing (WAAM) of Copper Alloy Cu1897”, Abid Shah et al. study the effects of process parameters in pulse cold metal transfer (CMT)-based WAAM of Cu1897 on weld bead penetration and porosity [34]. Their results suggest that a lower arc length correction (ALC) value and higher pulse correction (PC) should be used to enhance bead penetration and minimize porosity in WAAM of Cu1897.5.

3. Conclusions

In summary, this Special Issue offers a diverse range of contributions from leading experts that collectively exhibit the significant potential and challenges of AM. Since AM continues to transform the manufacturing landscape, we anticipate that this Special Issue will inspire further exploration, research, and instigate collaboration to unlock the full potential of 3D printing and AM technologies.

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