



## Editorial

## Editorial: Insights into advances in additive manufacturing across materials systems



In the past years, additive manufacturing (AM) has evolved from a prototyping tool into a practical industrial method for fabricating functional complex geometrical components and a single component with integrated multiple functions. Its versatility lies in its ability to process a diverse range of material systems while enabling precise microstructural and geometrical control. Recent publications in *Smart Materials in Manufacturing* have showcased a rich spectrum of AM-related research, encompassing novel material designs, process–microstructure–property relationships, and functional enhancements which find applications from biomedical engineering to aerospace and structural engineering.

Metallic AM has been the primary focus and has expanded rapidly across several aspects, including alloys development, process optimization, and surface/structure functionalization. The pursuit of alloys development has led researchers such as Liu et al. to develop a bioactive and fatigue-resistant Ti–Ta alloy by laser powder bed fusion (LPBF), yielding a high-strength alloy with enhanced biological performance for orthopedic implants [10.1016/j.smmf.2025.100086]. Simultaneously, growing interest in high-entropy alloys resulted in a review by Cagirici et al. [10.1016/j.smmf.2024.100058] who discussed the challenges and future prospects of AMed high-entropy alloys. The increasing applicability of AM for biomedical applications has also led to the potential of biodegradable zinc for orthopedic internal fixation and the printability of metallic suture anchors, which were reviewed by Nouri et al. [10.1016/j.smmf.2022.100005] and Chen et al. [10.1016/j.smmf.2023.100042], respectively. These reviews delivered impactful scientific insights that address the corrosion behavior of zinc-based alloys and highlight the clinical applicability of metallic sutures. On the process-optimization aspect, Lu et al. [10.1016/j.smmf.2025.100090] quantitatively identified a critical travel-speed threshold and a non-monotonic porosity relationship in wire arc AM (WAAM) of a Ti-22V-4Al alloy, while a review conducted by Siddiqui et al. [10.1016/j.smmf.2024.100059] explored the influence of different heat sources in WAAM on microstructural evolution and mechanical properties. Additionally, the influence of laser power on the interfacial bonding and overall mechanical behavior of TA15/TiAl bimetallic structures were investigated by Liang et al. [10.1016/j.smmf.2025.100087]. In the surface and structure engineering, Nouri et al. [10.1016/j.smmf.2022.100001] demonstrated antipathogenic surface modifications for AM metallic biomaterials, while Xiao et al. [10.1016/j.smmf.2025.100078] enhanced the wear resistance of AM-fabricated Co–Cr–Mo–W alloys by incorporating TiN nanoparticles to induce the formation of a dual-phase structure. From a macroscopic structural standpoint, iron scaffolds fabricated via LPBF led to enhanced mechanical performance of lattices that may find applications in orthopedic

scaffolds, bone implants, and even tissue engineering [10.1016/j.smmf.2025.100089].

AM ceramics has also witnessed profound advancements despite the inherent challenges related to brittleness and processing constraints. The accessible microstructural regime of Al<sub>2</sub>O<sub>3</sub>-ZrO<sub>2</sub> hypereutectic ceramics was expanded by Zhang et al. [10.1016/j.smmf.2024.100048], whose results enhanced mechanical performance effectively by LPBF. A high-strength, multifunctional, biphasic calcium phosphate/molybdenum disulfide composite strengthened with polyamide12 through AM was created by Ananth et al. [10.1016/j.smmf.2023.100037]. Furthermore, efforts by Belgin Paul et al. [10.1016/j.smmf.2024.100070] optimized direct ink-writing parameters for β-tricalcium phosphate scaffolds, balancing print fidelity with structural stability for tissue engineering, while a multi-process AM technique developed by Melentiev et al. [10.1016/j.smmf.2023.100043] combined fused deposition modeling (FDM), chemical deposition, and electroplating to produce multi-material structures with strong interfacial adhesion. In the wider context of composite fabrication, Gaikwad et al. [10.1016/j.smmf.2025.100084] provided an insightful review on fiber-reinforced polymer matrix composites for defense armor, focusing on fabrication approaches, reinforcement mechanisms, and performance metrics.

As for polymeric and bio-inspired AM, biomedical applications remain the dominant driver of innovation and process advancement. A study of the biodegradability, biocompatibility, and antibacterial activity of polylactic acid (PLA)–ZnO nanocomposites by Chong et al. [10.1016/j.smmf.2024.100069, 10.1016/j.smmf.2022.100004] brought valuable perspectives for a myriad of biomedical applications such as wound healing and tissue engineering. Focusing on lightweight components for neuroimaging devices, Mirabedini et al. [10.1016/j.smmf.2025.100085] found that thermoplastic-based composites offered superior wave-shielding properties as compared to conventional metals. Additionally, Baghbadorani et al. [10.1016/j.smmf.2025.100083] explored GelMA microneedle arrays, linking fabrication parameters to transdermal delivery performance, and examined the mechanical performance of these microneedles from processing to application. Suamte et al. [10.1016/j.smmf.2022.100011] reviewed scaffold-fabrication methods and identified optimal combinations of design parameters and material choices. Ani et al. [10.1016/j.smmf.2025.100076] reviewed the fatigue properties of AM polymeric metamaterials and summarized design principles, degradation mechanisms, and approaches for performance improvement, highlighting that fatigue properties are critically dependent not only on the presence of defects but also on the material geometries of auxetic designs. Extending into biomedicine applications, Adu et al. [10.1016/j.smmf.2024.100053] examined the challenges and advancements in elastomer/carbon nanotube nanocomposites with mechanochemical treatment, elucidating

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reinforcement mechanisms and diverse application scenarios, while Lee et al. [10.1016/j.smmf.2024.100044] provided a comprehensive review of polymer (nano)composites for phase change material-based thermal storage that are applicable in energy-storage systems. Besides biomedical applications, a novel paradigm toward AM fabrication was reviewed by Sola et al. [10.1016/j.smmf.2022.100013] where a “self-assembly meets AM” approach was introduced as a means to reconcile the disparity between nanoscale structure and macroscale design, which may offer unprecedented control over material performance in AM. Almansoori et al. [10.1016/j.smmf.2023.100023] explored a unique marble-PLA composite blend printed via FDM which finds application in decorative ornaments, architectural models, and art-based sculptures. Finally, Chua et al. [10.1016/j.smmf.2025.100073] unveiled the structure–property relationships of multilayered Helmholtz resonance-based acoustic resonators, highlighting the pronounced effects of the various pore geometries on resonance response.

Altogether, these studies demonstrate the breadth and dynamism of the current AM landscape. Metallic systems are progressing through integrated alloy design, process control, and surface functionalization; processing of ceramics and composites is surmounting inherent challenges through innovative routes and hybrid material strategies; and polymers alongside bio-inspired architectures are unlocking new biomedical and functional capabilities. The development of new feedstocks, such as smart, active, and stimulus-responsive materials, and the optimization of their processing parameters are opening new opportunities, motivating the adoption of AM across a broader range of applications, and unlocking unprecedented innovation. The synthesis of

material design, process innovation, and performance evaluation remains key to translating AM research into impactful real-world applications. As *Smart Materials in Manufacturing* continues to publish cutting-edge and interdisciplinary work, it will play a pivotal role in shaping the next generation of AM technologies and their integration into critical industrial sectors.

#### Declaration of generative AI in scientific writing

During the preparation of this work the authors used ChatGPT5 in order to check the grammar. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the published article.

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