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EDITORIAL

Overview: focus on laser-based manufacturing and materials processing

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The use of lasers in manufacturing and materials processing has revolutionised the way industries approach production, enabling unprecedented efficiency and precision [1]. Over the past few decades, laser-aided manufacturing and materials processing have evolved from ordinary applications to more advanced microfabrication and additive manufacturing techniques. The focus issue includes topical review papers and original research papers covering different aspects of the issue theme 'Laser-based Manufacturing and Materials Processing'. Many of them are briefly introduced below according to the elements of synthesis of advanced materials, surface modification, additive manufacturing, machining, welding, and process monitoring. Notably, the arrival of new technologies, including ultrafast lasers, has enabled unparalleled opportunities in research and development.

Laser-based materials synthesis offers a viable solution for creating customised materials with enhanced properties. Laser-based solution-phase synthesis techniques are employed to synthesise and pattern high entropy oxides with promising applications in catalysis, chemical sensing and electronics [2]. Synthesis of advanced materials, including photocatalysts, is now possible owing to the higher-power pulsed laser ablation technique [3]. Lie *et al* [4] proposed dealloying Ca-Si deposited by laser-based directed energy deposition (LDED) to produce thin silicon flakes to provide a scalable way of fabricating fine powders. Ronoh *et al* [5] employed picosecond laser pulses on Monel® alloy400 used in marine and piping environments to show that laser processing increased the surface roughness and decreased the hardness and Young's modulus with XPS showing the presence of NiO and CuO on the outer layer. Additionally, the authors identified the gap in carrying out more research on the corrosion behaviour of Monel® alloy 400 with picosecond lasers.

Among the recent developments in surface modification, laser-aided shock peening (LSP) has gained particular interest for improving the surface properties of materials and mitigating failure under mechanical stresses such as fatigue. The laser shock peening process capitalises on the plasma shock wave reflection to induce compressive stress onto the material. For instance, the LSP process transformed the residual tensile stress in the weld zone of martensitic stainless steel to that of the desired compressive stress field [6]. Gong *et al* [7] carried out in-depth work on the effect of laser scanning rate on the transition from laser ablation-dominated surface modification to that of surface melting and re-solidification of SS420 steel. They showed improvement in surface hardness due to significant changes in composition, phase precipitation, and laser-induced oxidation.

Laser-based additive manufacturing technologies such as selective laser melting (SLM) [8], selective laser sintering (SLS) [9], laser deposition manufacturing (LDM) [10], and lased-based direct energy deposition (LDED) have transformed how functional parts complex shapes and structures are produced. Using high-power lasers, metallic powders are selectively melted and fused layer by layer to build fully dense three-dimensional objects using SLM. The selection of laser processing parameters, such as energy density, defocusing distance, etc, are critical for melt pool geometrical characteristics and microstructure [8]. An exciting work revealed that ultrasonic waves could also influence the transition of Fe-based amorphous metallic glass from crystalline to amorphous aided by the inhibition of columnar grain and the creation of equiaxed grain [11]. Furthermore, using the support structure in SLM is crucial for the structural integrity of the components but requires post-processing operation for removal from the product. Pollicini *et al* [12] examined the impact of the design of block support structures on geometric characteristics of AISI 316 laminate features by assessing the minimal support/part contact areas promoting cost-effective support removal. Xie *et al* [13] investigated the process parameters of electrode induction melting gas atomisation for producing NiTi powder for subsequent SLM process to develop a NiTi porous structure.

Laser powder bed fusion (LPBF) technology is characterised by process-induced cracks and defects due to unexpected melt pool dynamics due to the laser-induced keyhole. An exciting work by Li [14] studied the effect of sulfur content in 316L LPBF powders by proposing a 3D powder-scale transient computational fluid dynamics model to investigate the sulfur-induced transitions of thermo-capillary and melt pool dynamics. Another work by Bai *et al* [15] contributed to understanding the best LPBF process parameters selection, control, and post-heat treatment to produce Ni-based Hastelloy X that exhibits a favourable strength-to-ductility ratio.

Another laser-based AM technique, LDED, involves the deposition of materials under a Laser beam to create new parts and repair damaged components. Shiwei Ci *et al* [16] carried LDED on aircraft turbine engine blade material nickel-based single crystal (SX) superalloys to ensure epitaxial growth of dendrites via the control of process parameters. The laser parameters can suppress existing issues, such as the formation of dendrites and stray grains, cracks, and unwanted stresses. The second study addressed the effect of parameters on the formation of cracks in Ti-48Al-2Cr-2Nb alloy for low-pressure turbine (LPT) blades in gas engines [17]. TiAl alloy has emerged as the preferred structural material over nickel-based superalloy, which is anticipated to result in a 20%–30% reduction in the structural weight. Wang *et al* [18] fabricated a new type of high-strength Ti-6Al-2Mo-2Sn-2Zr-2Cr-2V alloy by LDED for aerospace applications. The microhardness and tensile strength of L-DED Ti-622222 improved, but elongation deteriorated, exhibiting both ductile and brittle fracture mechanisms. Shang *et al* [19] demonstrated that the mechanical properties, including ductility of L-DED Ta-containing Ti6Al4V, could be enhanced by selecting the appropriate alloying composition and subsequent heat treatment of solution treatment and ageing.

Laser machining has revolutionised traditional manufacturing processes with its high precision and versatility. It has allowed manufacturers to cut, engrave, turn, and drill materials with exceptional accuracy and speed. Researchers have reported results of parameters and factors that could negatively affect the machining quality. For instance, laser percussion drilling is applied in complex, compact electronic devices that use miniaturised, multi-composite printed circuit boards with high-density interconnects (HDI). The drilling quality and geometry of microvia can be affected by ultrashort pulsed laser heat accumulation in MHZ burse mode because the insulating Ajinomoto build-up film (ABF) layer exhibits voids and even delamination [20]. Similarly, the combined action of ultrasonic-vibration-laser assisted turning (UVLAT) energy has demonstrated a notable advancement in machining process capabilities by eradicating the usage of cutting fluids, making the process sustainable. However, Deswal and Kant [21] showed that selecting the vibration direction is crucial in defining the surface quality and roughness parameters. The selection of radial direction caused surface damage with pinpoint hammering and particle adherence on the workpiece component.

Another manufacturing branch relates to joining processes, wherein laser welding has become a preferred method due to numerous advantages, such as process monitoring and control [22]. A comprehensive topical review article by Khan [23] highlights one of the mainstream automotive applications in tailor-welded blank technology, wherein strategies to prevent fusion zone softening, ferrite suppression, and potential process optimisation techniques are discussed. Dissimilar materials welded with unequal thickness are another challenge in forming defects. Lina *et al* [24] targeted automobile clutches application to demonstrate the advantage of laser wire filling welding to achieve higher tensile strength in contrast to autogenous laser welding of low and medium carbon steel by varying laser power, weld speed, wire speed and butt gap. Zhou *et al* [25] evaluated the cryogenic fracture toughness and crack propagation mechanism of dissimilar materials welding of SA645 steel for storing liquefied ethane gas and 304L steel for pipes valves and support plates connected to the tank. Zhe *et al* [26] demonstrated that the laser welded joint of 22MnB5-TRIP590 steel with magnetic field assistance and post-weld heat treatment has superior overall mechanical qualities.

Laser process monitoring and control systems have further enhanced the reliability and quality of laser-based manufacturing. In-process monitoring of thermal cycles for duplex stainless steel laser welding [22] was carried out using an infrared pyrometer to obtain information about the weld pool's peak surface temperature and rate of cooling correlated with the evolution of microstructures and their corresponding mechanical properties. Additionally, Aleem *et al* [27] investigated the possibility of using auditory signal monitoring for laser cleaning corroded boron steel to confirm the presence of rusting ablation by the Mel Frequency Cepstral Coefficient (MFCC). The precise control of scanning speed, frequency, and number of marking loops was essential to avoid overexposure of the laser beam and to avoid engraving effects or groove formation indicated by the trend variation in MFCC. This study shows whether the cleaning process ceases before any morphological changes ensue.

The focus issue will offer readers an excellent overview of the latest advancements in laser-based manufacturing and materials processing, indicating a transition towards applied research. We want to take this opportunity to express our gratitude to all the authors, adding to the success of this Special Issue with 'Focus on Laser-based Manufacturing and Materials Processing', as well as all the reviewers who volunteered their time and their feedback helped to enhance the quality of the papers that were published.

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Data availability statement

No new data were created or analysed in this study.

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Conflicts of interest

The authors declare no conflict of interest.

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