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Abstract

Sinter-based AM technologies – New opportunities for medical technology

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Additive manufacturing (AM) with metals, particularly titanium, is well established in the medical field and is currently dominated by laser powder bed fusion (PBF-LB), which accounts for up to 80% of the market volume in terms of installed machines and part revenue. An important exception is electron beam powder bed fusion (PBF-EB), which is widely used for acetabular components or knee implants, especially tibial and femoral components with porous. Other metallic AM processes have so far played only a minor role in clinical products.

However, PBF-LB and PBF-EB exhibit inherent limitations, including restricted surface quality, usually Ra ≈ 15 µm for as built surfaces, limited achievable resolution for fine features (~200–250 µm), and the labor-intensive removal of support structures, which can be particularly problematic for complex or filigree geometries. Sinter-based processes address several of these issues. Technologies such as binder jetting, lithography-based metal manufacturing (LMM), MoldJet, GelCasting and related approaches can provide significantly improved surface roughness (down to approximately Ra ≈ 1 µm without post-processing) and enable much higher geometric resolution with feature sizes down to ~ 50–100 µm, depending on the specific process. In addition, these processes offer the potential for substantially higher productivity and lower part costs, for example in the production of dental implants or standardized medical device components with reported up to at least an order of magnitude higher build rates compared to PBF-LB. These benefits are counterbalanced by challenges, in particular the “first-time-right” issue related to shrinkage control, distortion and defect formation during debinding and sintering which often require experimental calibration and simulation to achieve clinical acceptable yields.

This contribution presents an overview of the latest advances in these technologies, which have so far been perceived largely as niche processes in medical technology. We demonstrate development examples including resorbable implants made from molybdenum, possible mass customization for dental and hip implants produced by metal binder jetting, components for medical CT scanners manufactured via additive screen printing, and surgical instruments realized with LMM and MoldJet. The paper discusses design considerations and process chains and evaluates where sinter-based metal AM can complement or partly replace PBF-LB and PBF-EB in future medical device manufacturing.

AUTHOR’S STATEMENT

Conflict of interest: The authors declare no conflicting interests. Informed consent: Informed consent has been obtained from all individuals included in this study.

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