Ultra-precision surface treatment of directionally additive manufactured Al-Si alloy

Pavithran K[1], Jibin Boban[1,2#], Afzaal Ahmed[1] and Dennis Wee Keong Neo[3]

1 Department of Mechanical Engineering, Indian Institute of Technology (IIT) Palakkad, Kerala, 678623, India
2 Mikrotools Private Limited, Jalan Bukit Merah, 159456, Singapore
3 Singapore Institute of Manufacturing Technology (SIMTech), CleanTech Two, 636732, Singapore
Corresponding Author / Email: jibin@mikrotools.com, TEL: +91-9526943002

KEYWORDS: Additive Manufacturing, Micro-feature, Diamond turning, Ultra-precision machining

Additive manufacturing (AM) is a swiftly advancing domain that facilitates the production of intricate and complex parts with desired customization. The technology creates opportunities for batch production with negligible wastage of material. However, the AM parts tend to have poor surface integrity, which adversely affects the functional performance of the component. The presence of surface defects/irregularities like balling defects, spattering, inadequately melted particles, etc. can hinder the acceptability of AM parts in industries. Therefore, post-treatment of AM surfaces is highly important to meet industrial quality standards. The generally adopted post-treatment methods like laser polishing, chemical finishing, abrasive fluidized bed machining, etc. have been proven to contribute sub-micron surface finish on metal AM parts. However, certain applications in space and defense sectors demand extremely smooth surfaces with nano-level finish on components like metallic mirrors, reflective surfaces, solar concentrators etc. Therefore, the present study explores the potential of ultra-precision diamond turning in improving the surface quality of additively manufactured metallic surfacesbeyond sub-micron regime. Considering the potential of Aluminum alloys in reflective optics applications, laser powder bed fused AlSi10Mg is considered in the study to assess the ultra-precision machining performance in terms of surface quality and form accuracy. The results from the study showed that the build orientation of directionally printed samples (horizontal and vertical) played a vital role in deciding the post-treatment process performance. After implementing the ultra-precision finishing process, nano-level surface finish was achieved on both horizontally (Ra= ~39.8 nm) and vertically (Ra= ~29.0 nm) printed samples with the latter being smoother. Moreover, micro-cutting experiments confirmed that the vertically built samples experienced larger forces (~0.63 N) than horizontal ones (~0.59 N) owing to the microstructural differences with respect to orientation. Further, the study showed that micro-feature generation can be successfully accomplished on additively printed AlSi10Mg samples regardless of the build orientation. Thus, the proposed approach can be useful in elevating the potential of laser powder bed fused AlSi10Mg in metallic optics applications.

.

Word count: Not more than 500 words