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Publication date:
2018

Document Version
Peer reviewed version

Reproduction of multi-hierarchical structural surfaces by vat-photopolymerization

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This study investigates the intersection of bio-inspired surfaces and additive manufacturing (AM), with the aim of determining the feasibility and viability of leveraging 3D printing technologies to replicate surfaces that mirror those found in nature. These surfaces, like metamaterials, are constituted by arrays of microstructures arranged at multiple hierarchical levels. The ability to rapidly and inexpensively reproduce microstructures using AM at micro scale would thus serve to enable the scientific community to conduct optimization of 3D surface model designs. This would allow for improved forecasting of surface properties and behaviors before investment in other micromanufacturing methods. The investigation was carried out using a state-of-the-art vat photopolymerization AM machine-tool suitable for precision manufacturing at the micro dimensional range developed, built and validated at the Technical University of Denmark. It was shown that it was possible to reproduce multihierarchical micro features inspired by the surface of the Tokay gecko toe. Ultimately, voxel resolution of 7.6 µm was visualized. Moreover, two more intricate designs were fabricated with the same parameters, yet showing higher hydrophobicity with a water contact angle of 124°±0.10°, due to their increased density and decreased feature size, not due to its material properties. These results indicate the possibility of using precision AM for a rapid, easy and reliable fabrication of working functional surfaces, which can also be applied to the design and fabrication of metamaterials.

[1] M. P. Murphy, S. Kim, and M. Sitti, “Enhanced Adhesion by Gecko-Inspired Hierarchical Fibrillar Adhesives,” *ACS Appl. Mater. Interfaces*, vol. 1, no. 4, pp. 849–855, Apr. 2009.