High-Throughput Patterning of Sub-Diffraction 3D Structures Through Projection of Femtosecond Light

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High-throughput fabrication techniques for generating arbitrarily complex three-dimensional structures with sub-diffraction nanoscale features are desirable across a broad range of applications including healthcare, transportation, and computing. Two-photon lithography (TPL) is a promising additive manufacturing (AM) technique that relies on nonlinear light absorption to fabricate complex 3D structures with polymeric nanoscale features. However, commercially available serial point-by-point writing scheme of TPL is too slow for many applications. We have developed a high-throughput nanoscale AM technique based on parallelization of TPL.[1] Our technique has increased the processing rate by a thousand times while preserving the nanoscale feature sizes. It relies on simultaneous spatial and temporal focusing of an ultrafast laser to implement projection-based layer-by-layer printing using arbitrarily patterned light sheets. The first part of this talk will focus on how we broke the traditional tradeoff between rate and feature size – a tradeoff that had persisted in the field for more than two decades and was considered unbreakable. The second part will focus on how one may expand the material palette to 3D print various polymeric, metallic, and ceramic structures on the nanoscale. Our method allows access to difficult to explore regions in the design space, increasing both the potential for cost-effective high-throughput processing and the geometric complexity of the printed objects.

[1] Saha, S. K., Wang, D., Nguyen, V. H., Chang, Y., Oakdale, J. S., & Chen, S. C. (2019). Scalable submicrometer additive manufacturing. Science, 366(6461), 105-109.

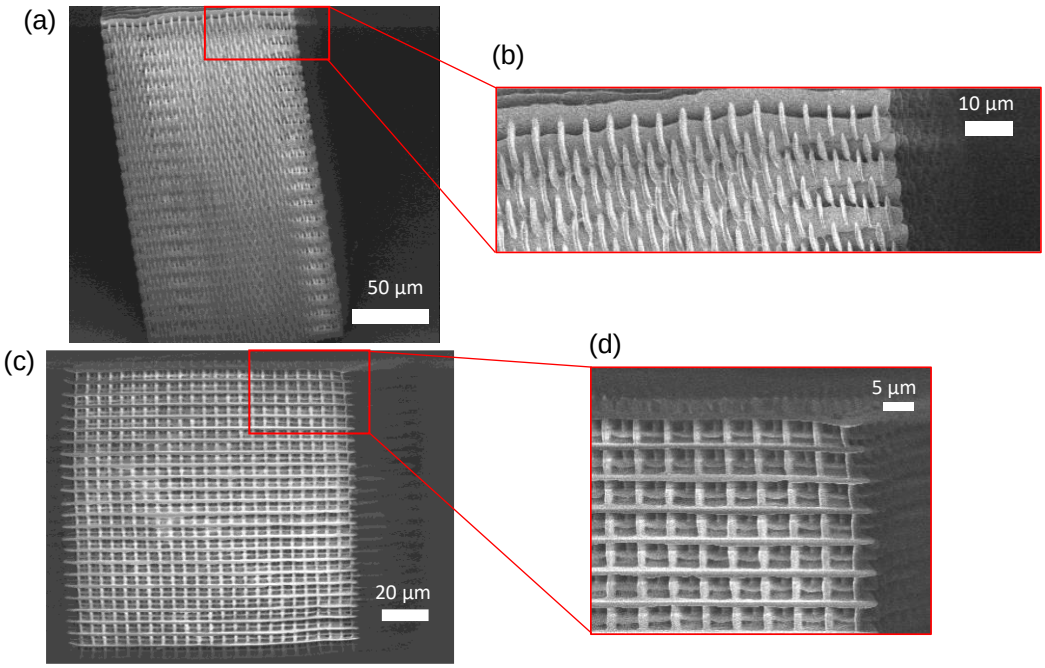

Figure 1: 3D Woodpile with nanoscale features: A 125 µm × 125 µm × 270 µm woodpile 3D structure printed via projection TPL. (a) and (b) Side view of the woodpile; (c) and (d) top view of the woodpile.