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Sandia National Laboratories

3D-printed polymer lattices

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Context and References

Our goal is to create lattice structures with well defined pore geometries to precisely define how fluids flow through them and come into contact with the solid. We would like to create a wide range of pore sizes. 3D printing of photopolymers is a promising approach to this.

We have a standard design that prints pores that are small as possible within instrument constraints, generally near the voxel size of the printer. We print the parts at an angle (that of a cube diagonal) so the fluid must zigzag through the pores. It is described in the following references:

M. Salloum, D.B. Robinson. A Numerical model of exchange chromatography through 3 - D lattice structures”, AIChe J. 64(5) 1874-1884, 2018. 10.1002/aic.16108

D.B. Robinson. 3D-Printed Apparatus for Efficient Fluid-Solid Contact. US Patent 10493693 B1 (2019).

C.G. Jones, B.E. Mills, R.K. Nishimoto, D.B. Robinson. Electroless Deposition of Palladium on Macroscopic 3D-Printed Polymers with Dense Microlattice Architectures for Development of Multifunctional Composite Materials. J. Electrochem. Soc. 164:D867, 2017.

D.B. Robinson. Hierarchically Porous Structures Prepared by Electrodeposition Onto 3D-Printed Substrates. SAND2018-10698C

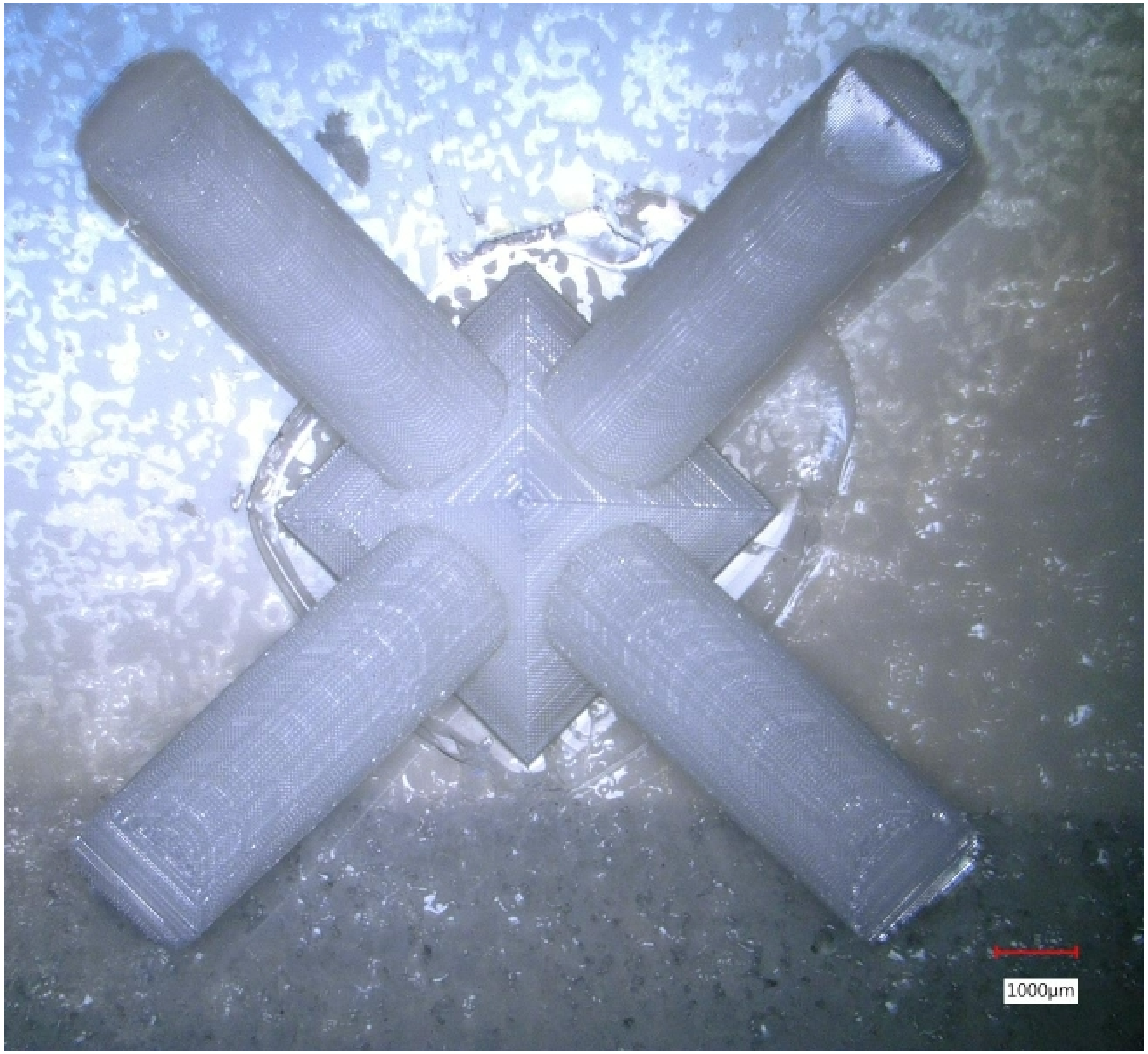
Acrea3D is commercializing the technology described in these papers:

H. Gong, B.P. Bickham. A.T. Woolley, G.P. Nordin. Custom 3D printer and resin for 18 μm × 20 μm microfluidic flow channels. Lab Chip 17 2899-2909, 2017. 10.1039/c7lc00644f

G. Nordin, H. Gong, M. Viglione, K. Hooper, A. Wooley. 3D printing for lab-on-a-chip devices

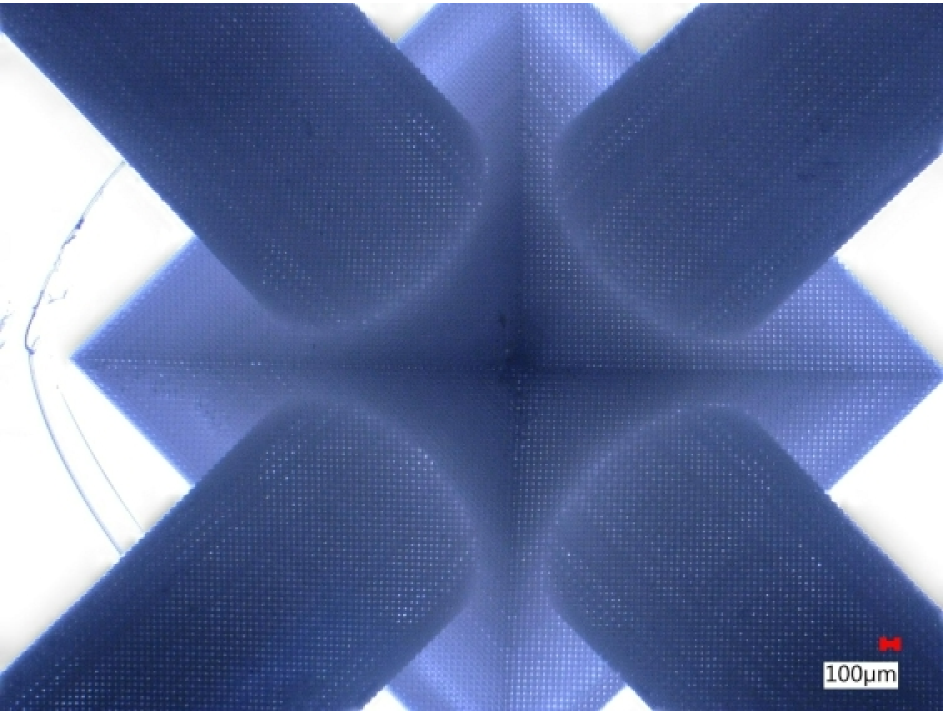
23 µm lattice overview

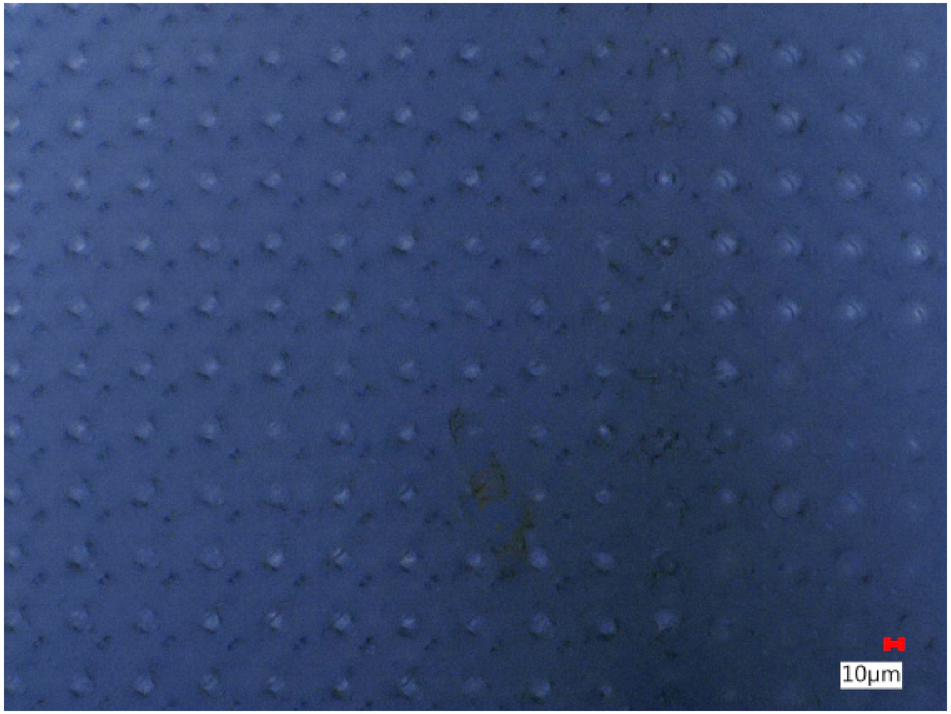
The part consists of 2 mm cylinders extending from the faces of a pyramid. There are some defects near the ends of the cylinders. Including a support fin or posts under the cylinders might help in the future.



23 µm lattice pores

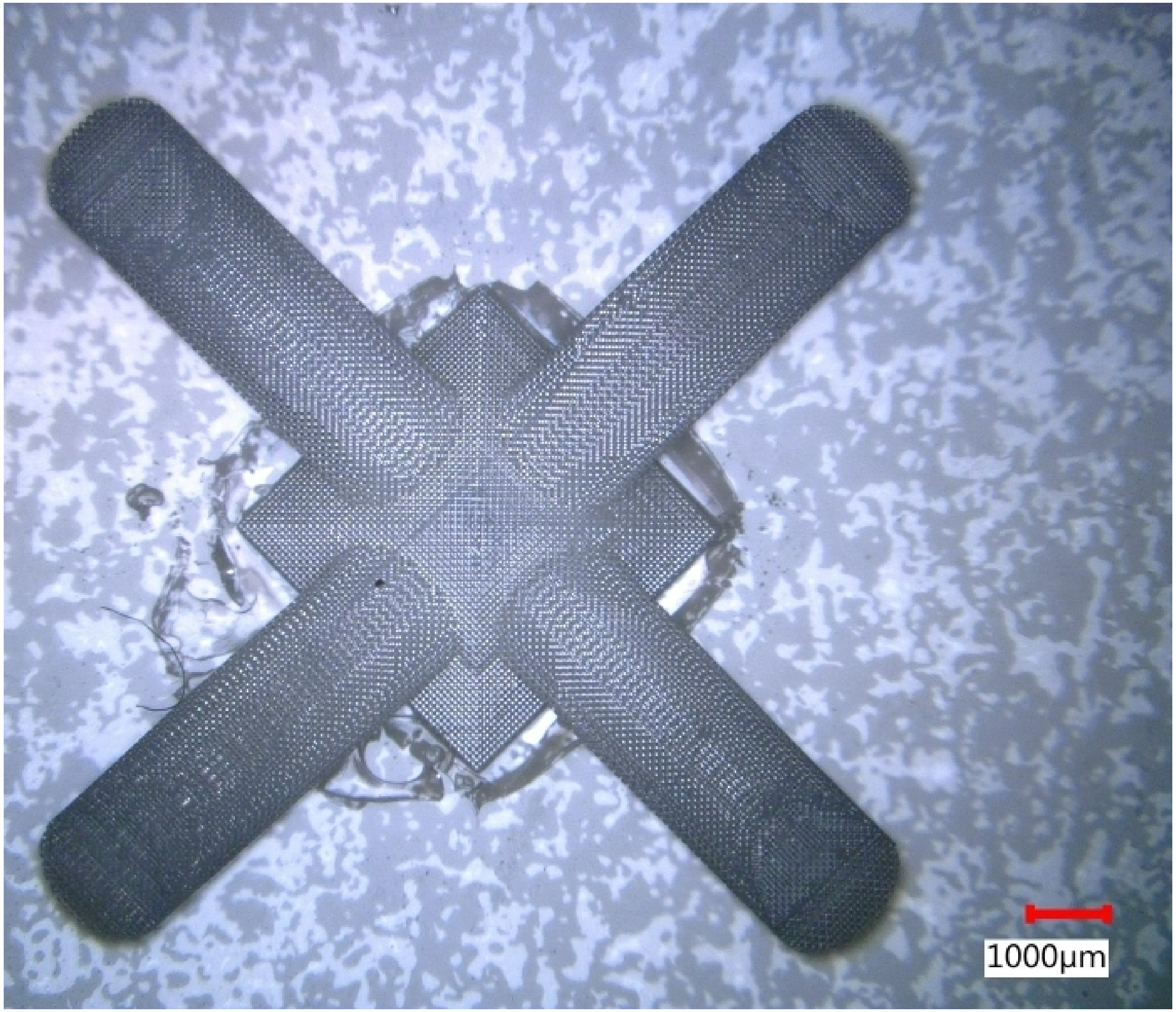
The pores appear to have printed uniformly throughout the part. However, the part was designed with a strut size equal to the pore size. The pores are clearly smaller than the struts and the prescribed pore size. In a future part, we could compensate for this by making the struts relatively thin. The voxel size is 7.6 µm, providing some flexibility to adjust this.





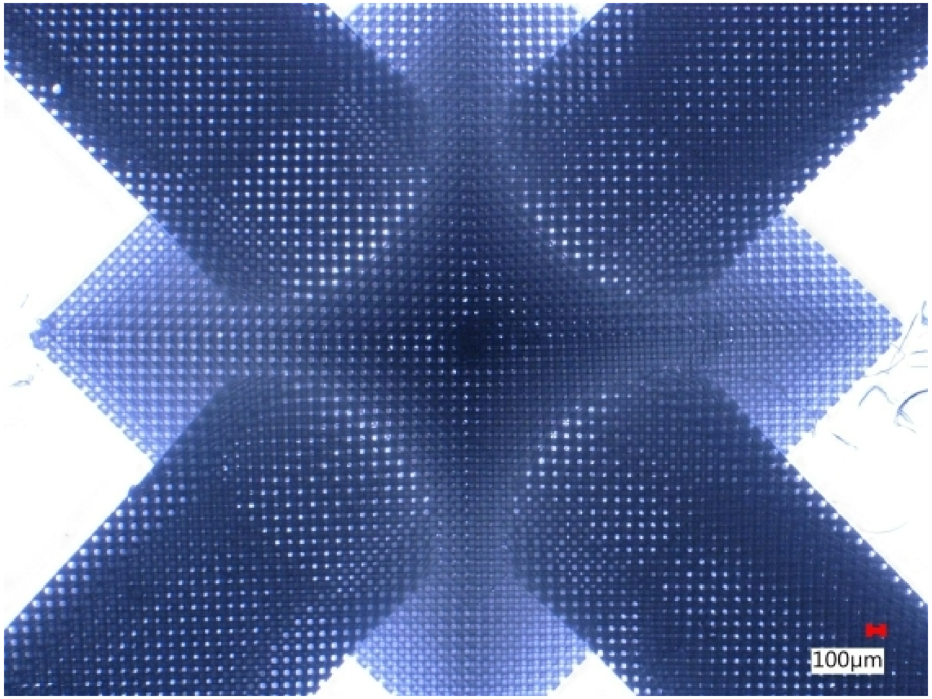
46 µm lattice overview

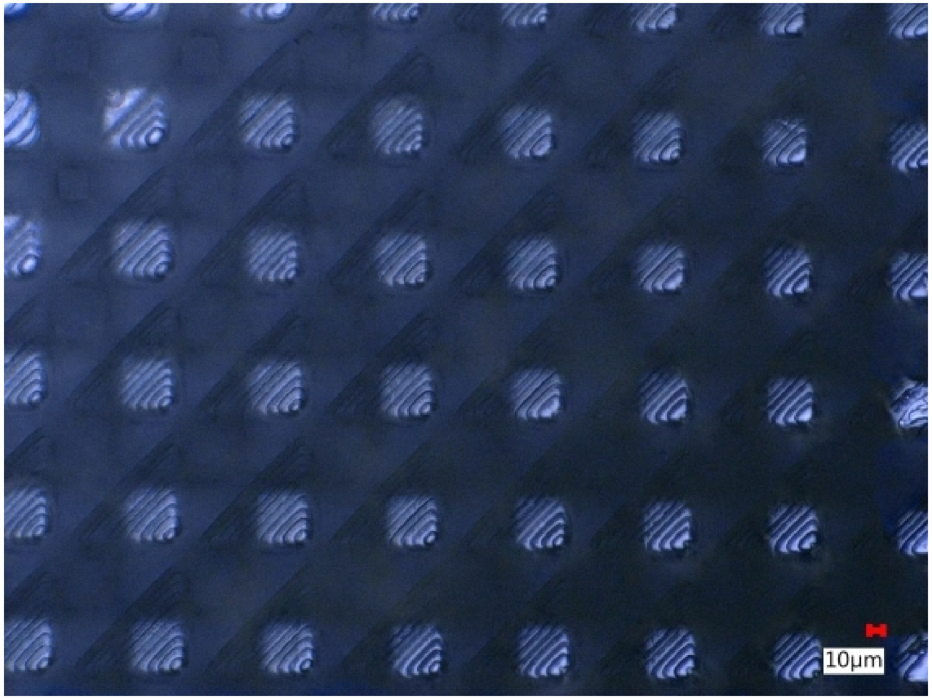
We also printed a part designed with 2x larger pores and struts. Again there were a few defects near the end.



46 µm lattice overview

The larger pores in this part appear quite uniform. The ratio of pore size to strut size in this part is closer to 1, and each is closer to the nominal value.





Future opportunities

- In our prior publications, Bernice Mills has helped us use X-ray tomography to inspect polymer lattices for presence or absence of defects in greater detail; this could be valuable for these parts.
- Our inspection of the parts could lead to design improvements such as the use of support structures and the optimization of strut thickness.
- In our prior publications, we used chemical methods to add functional materials to polymer lattices. New methods for this are emerging, as described in:
  Daryl W. Yee and Julia R. Greer. Three-dimensional chemical reactors: in situ materials synthesis to advance vat photopolymerization. Polymer Int. 70 (7) 964-976, 2021. 10.1002/pi.6165
- Flow tests of parts with varying pore and strut size may demonstrate a novel method to tailor fluid flow.
- Our previously published COMSOL flow model could help evaluate this concept.