Supporting Information

for

A shoe-box-sized 3D laser nanoprinter based on two-step absorption

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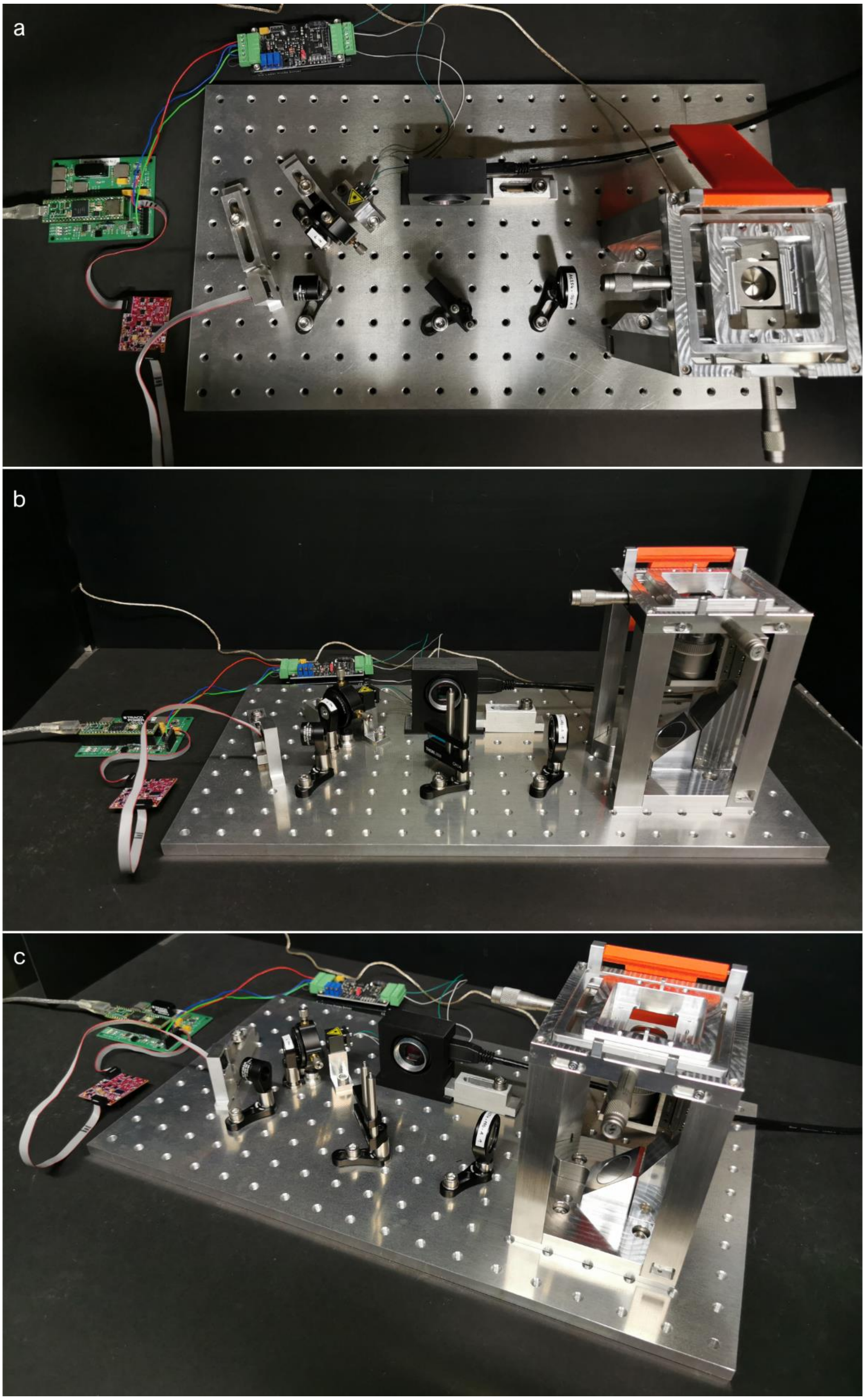

Figure S1. Additional photographs of the entire setup. a Zoomed-out top view, comprising all optical and electronic components. **b** Oblique side view. **c** Different perspective.

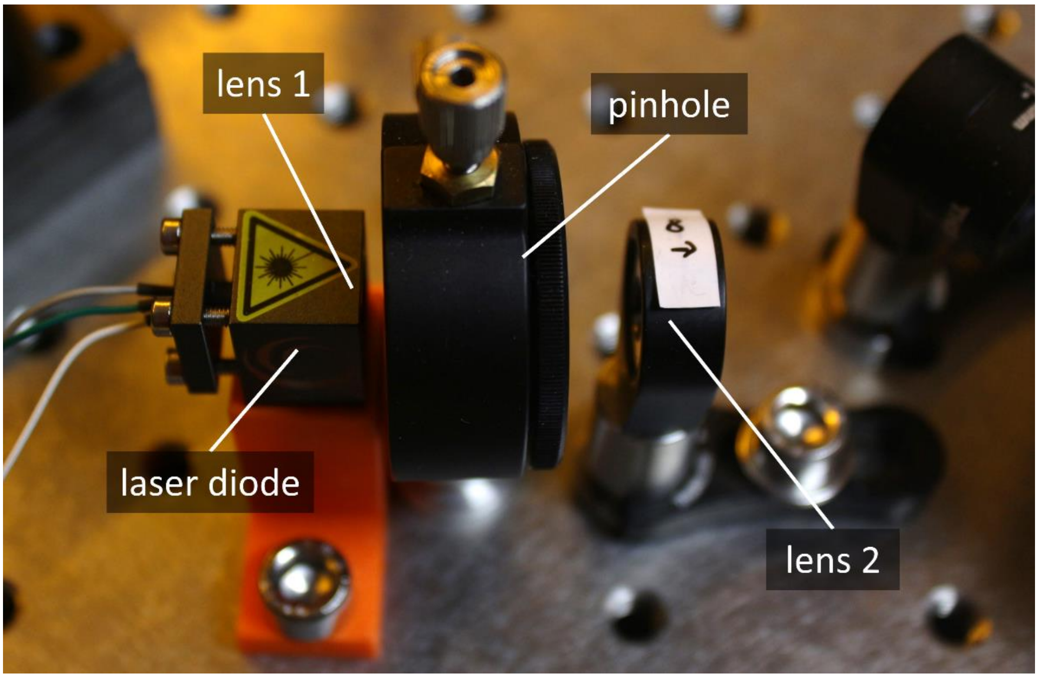

Figure S2. Close-up photograph of the first part of the optical beam path of the shoe-box-sized 3D laser nanoprinter. The edge-emitting semiconductor laser diode is mounted together with the first lens in a small non-temperature-controlled holder. The first lens focusses the elliptical beam through a $5\ \mu m$ pinhole mounted on an *xy* translation stage. The second lens collimates the cleaned-up laser beam.

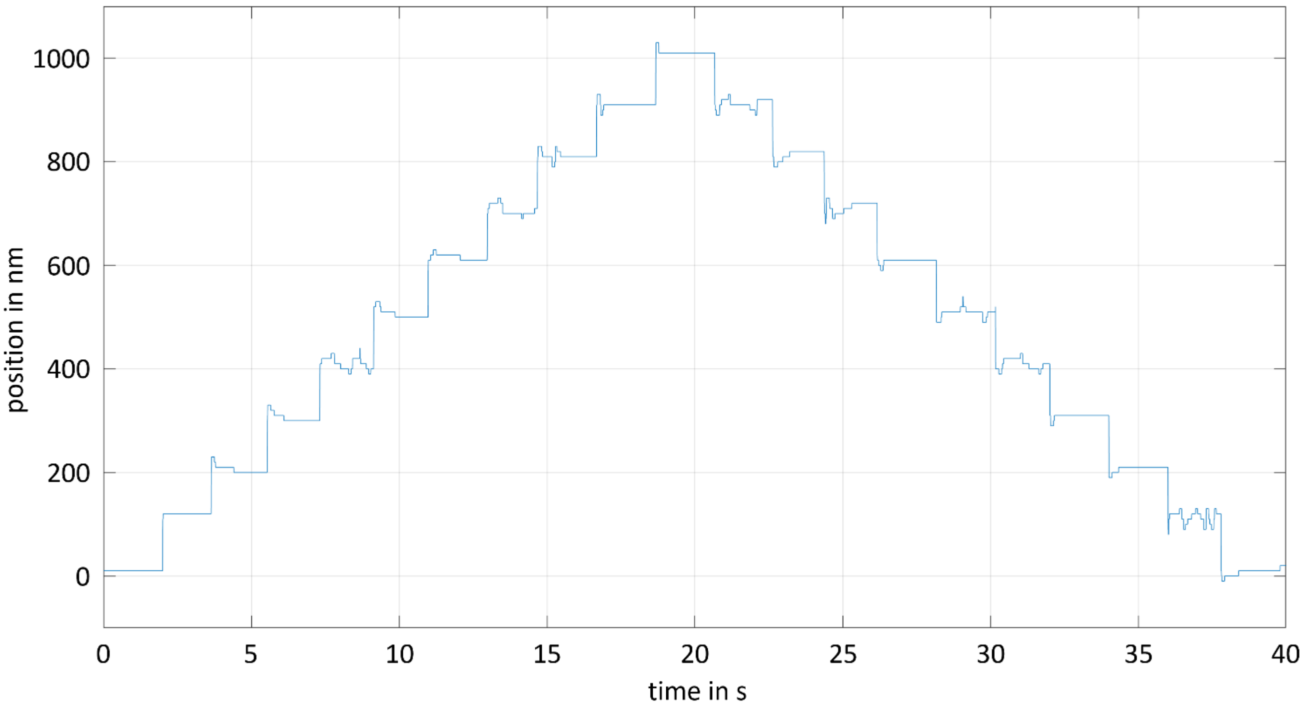

Figure S3. Plot of a typical $100\ \mathrm{nm}$ step pyramid. The measurement is performed via the software of the stage provided by NanosInstruments. A step-up and step-down routine is run with 10 repetitions of $100\ \mathrm{nm}$ steps with a minimal step size of the stage of $10\ \mathrm{nm}$. The delay time is set to $2\ \mathrm{s}$. These values fit to the $100\ \mathrm{nm}$ slicing distance used for printing and a common period for one layer to be printed.

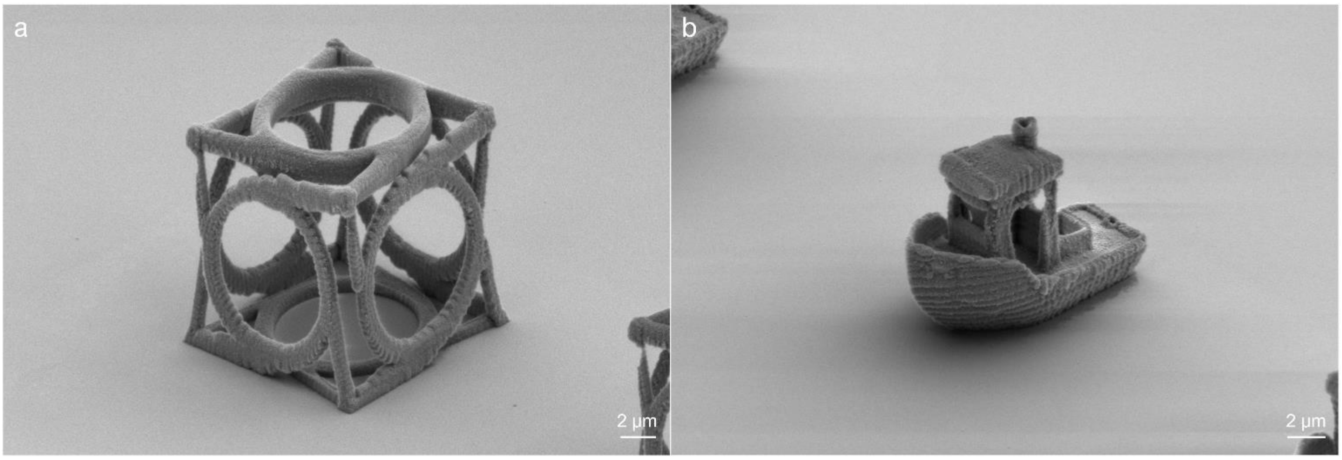

Figure S4. Scanning electron micrographs of 3D structures printed with the Motic $\mathbf{NA = 1.25}$ microscope objective lens. a A single unit cell of a chiral mechanical metamaterial. **b** #3DBenchy structure. Both structures are printed with a scan velocity of $1\ \mathrm{mm\ s^{-1}}$ and a hatching and slicing of $50\ \mathrm{nm}$ and $100\ \mathrm{nm}$, respectively. The laser powers used for printing are larger by a factor of 1.3 as compared to the prints with the Leica $\mathrm{NA} = 1.4$ microscope objective lens, as measured in the beam path. Additionally, the entrance pupil of the Motic objective lens is slightly smaller, leading to more pronounced beam clipping and power reduction as compared to the Leica lens.

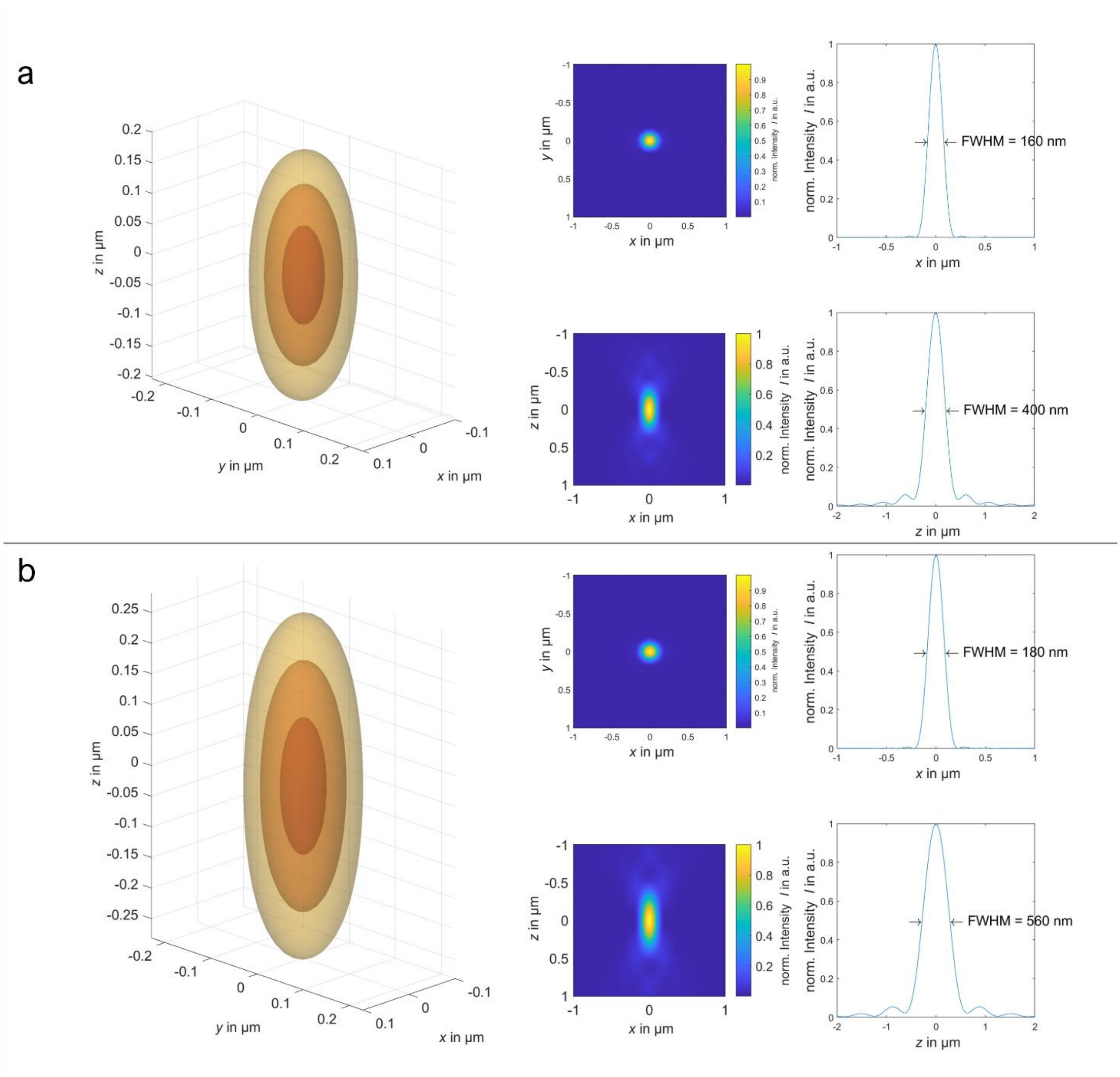

Figure S5. Calculations of the point-spread-function of the laser focus for the two different microscope objective lenses. a Leica HCX PL APO 100×/1.4−0.7 Oil CS objective lens and **b** Motic EC PL 100×/1.25 objective lens. On the left side, the iso-intensity surfaces at 90%, 70%, and 50% of the maximum intensity are depicted. The center row shows 2D cuts (*xy*-plane (top) and *xz*-plane (bottom)) through the corresponding normalized intensity profile. On the right-hand side, 1D cuts along the *x*-axis (top) and *z*-axis (bottom) are plotted. The full width at half maximum is indicated. The underlying intensity profiles are calculated using the modified Richards & Wolf integrals [1].

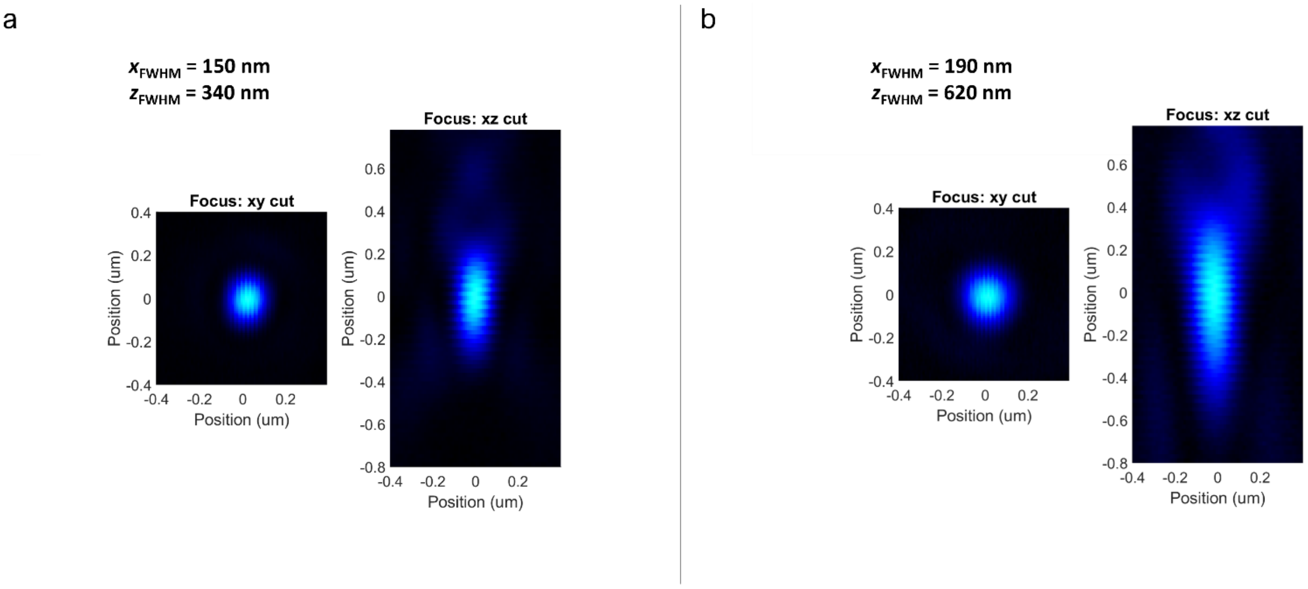

Figure S6. Measured point-spread-function of the laser focus for the two different microscope objective lenses. a Leica HCX PL APO 100×/1.4−0.7 Oil CS objective lens and **b** Motic EC PL 100×/1.25 objective lens. The laser focus is raster scanned over a sample containing $80\ \mathrm{nm}$ gold nanoparticles within the *xy*-, *xz*-, and *yz*-plane and the scattered light is measured with a photodiode. The resulting full widths at half maximum are calculated and depicted in the plots. The measurements were conducted using a different setup and different beam parameters. The defocus was optimized for minimum aspect ratio of axial to lateral full width at half maximum of the point-spread-function. The obtained defocus values were adopted to the shoe-box-sized 3D laser nanoprinter using the wavefront sensor.

Figure S7. Photograph of the two microscope objective lenses Motic EC PL 100×/1.25 (left) and Leica HCX PL APO 100×/1.4−0.7 Oil CS (right).

Table S1. Comparison of typical costs for different components of a state-of-the-art two-photon 3D laser nanoprinter and our shoe-box-sized 3D laser nanoprinter based on two-step absorption.

	state-of-the-art two-photon 3D laser nanoprinter		shoe-box-sized two-step 3D laser nanoprinter	
light source	femtosecond laser	100 k€	laser diode	40 €
power modulation	AOM	5 k€	-	
scan unit	galvo scanner	5 k€	MEMS scanner	1.5 k€
stages	piezo/motorized	each 5 k€	compact piezo stage	3.7 k€
objective lens	100×/1.4	5 k€	100×/1.4 or 100×/1.25	5 k€ or 150 €
control unit	FPGA	10 k€	microcontroller	30 €
sum		**130 k€**		**10.3 k€ or 5.4 k€**

References

1. Richards, B. & Wolf, E. Electromagnetic diffraction in optical systems, II. Structure of the image field in an aplanatic system. *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences* **253**, 358–379 (1959).