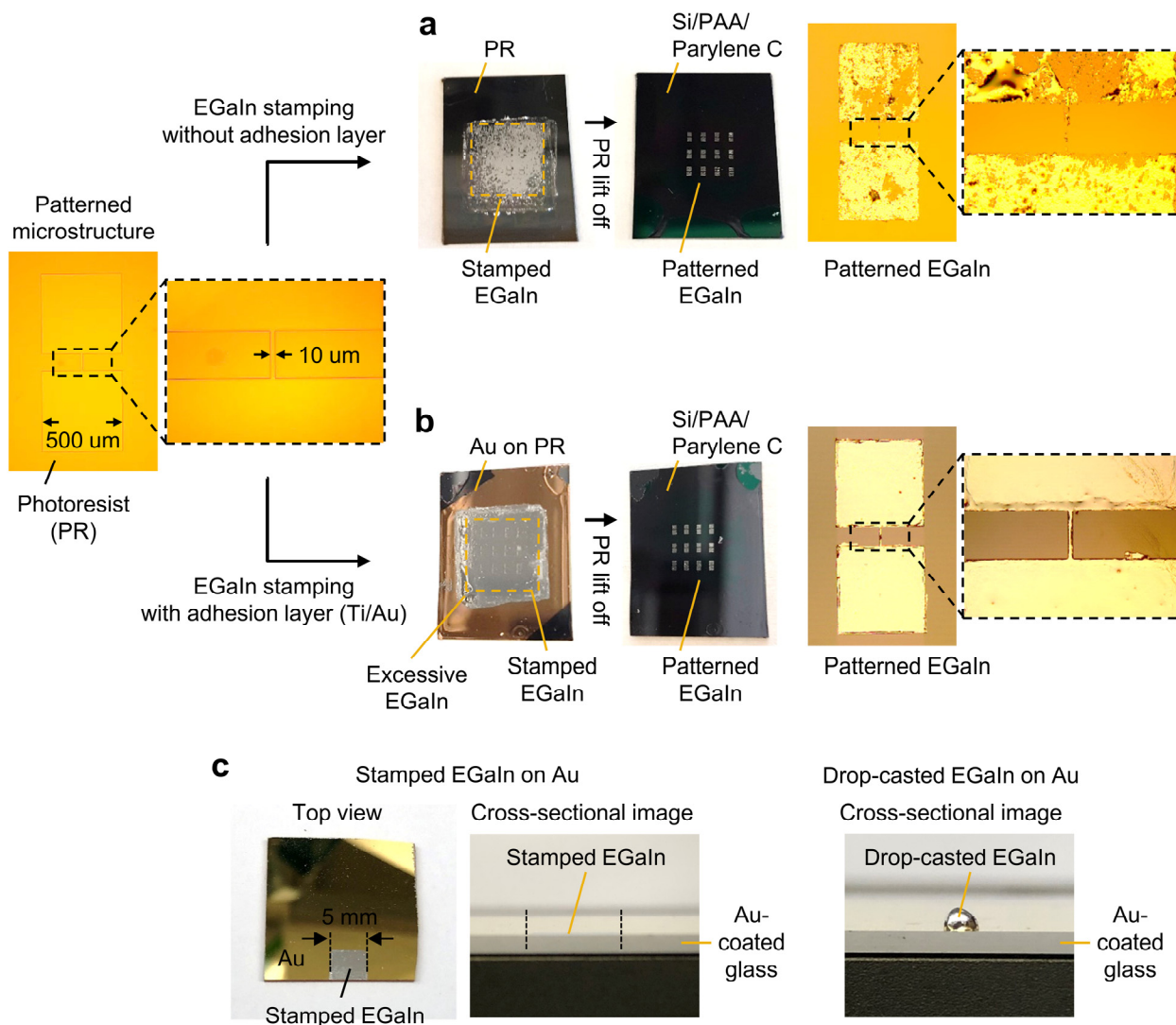
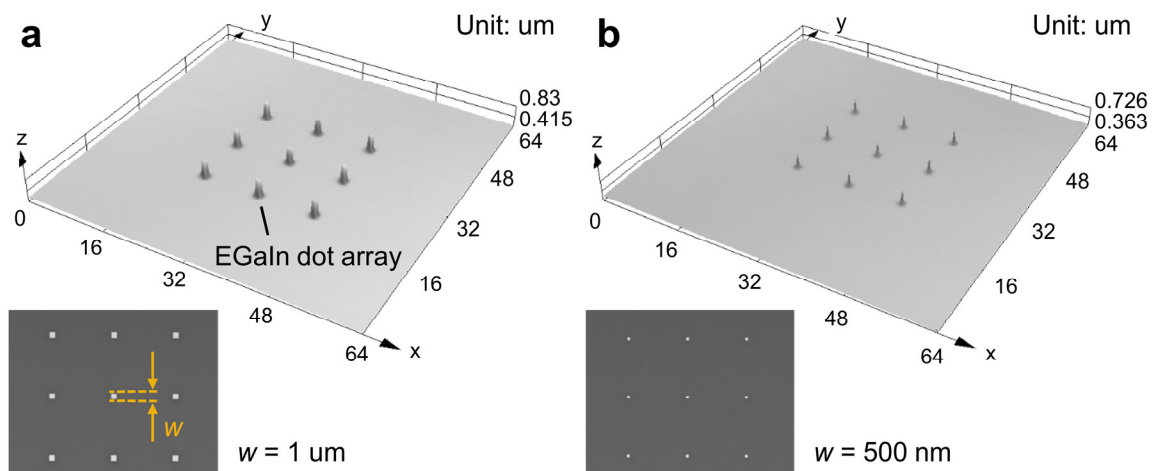


Supplementary Information
for
Nanofabrication for all-soft and high-density electronic devices based on
liquid metal

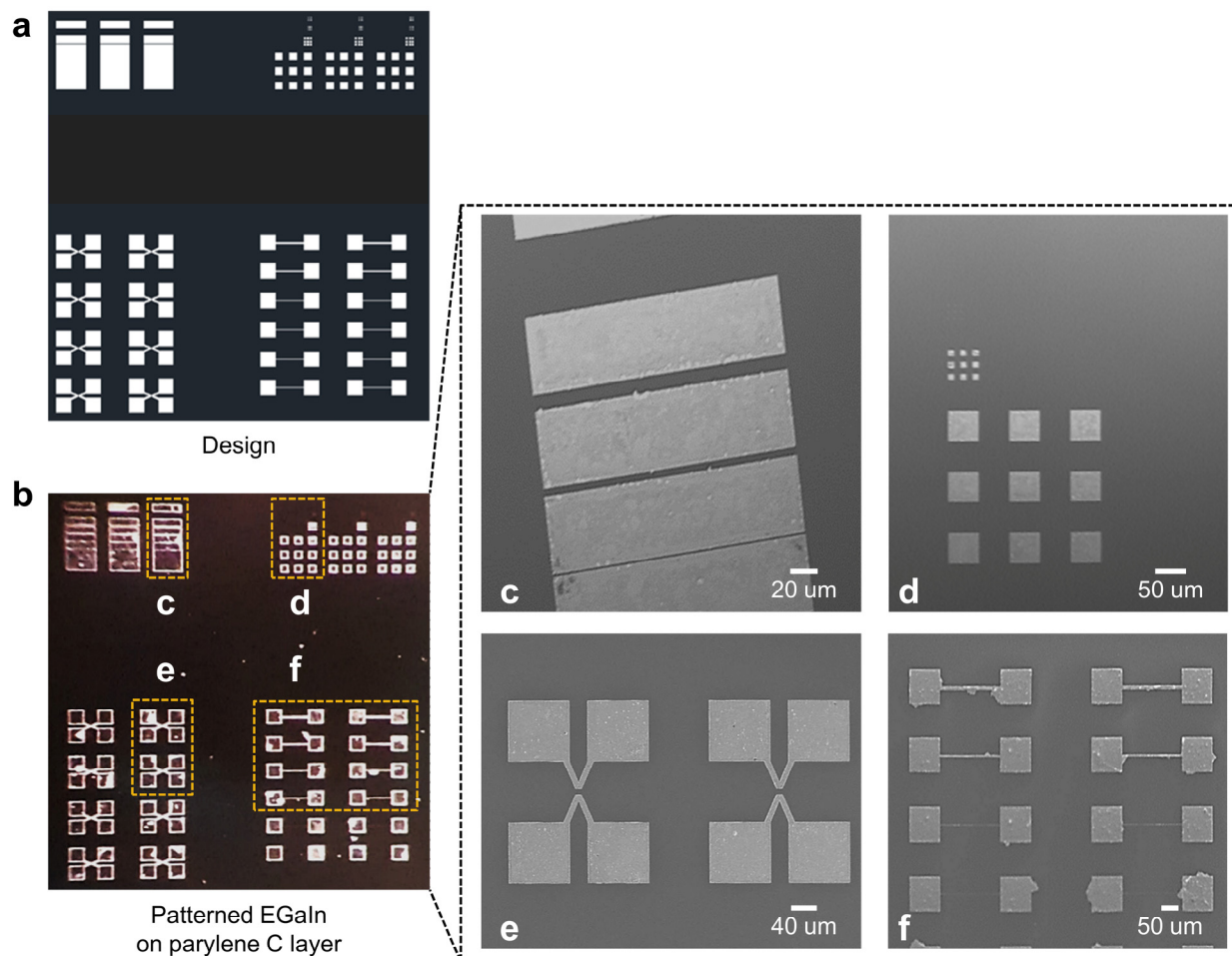
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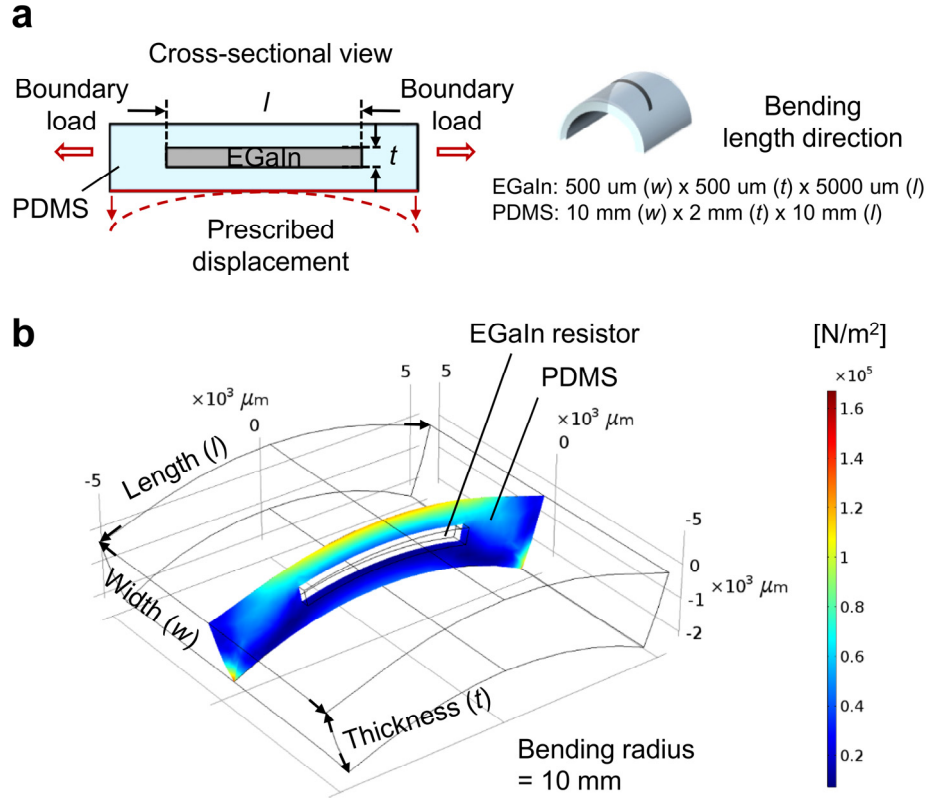
Supplementary Figure 1. Wetting characteristic of EGaIn stamping process. EGaIn stamping process on patterned PMMA structures **a** without adhesion layer and **b** with Au adhesion layer. **c** Cross-sectional images of uniformly spread stamped EGaIn on Au adhesion layer, in comparison with drop-casted EGaIn on the same Au adhesion layer. The contact angle of the EGaIn droplet on the Au surface is $\approx 130^\circ$ ^{39,52}. The stamping process enables uniform deposition on the Au adhesion layer, resulting in a dramatically reduced contact angle of almost zero.



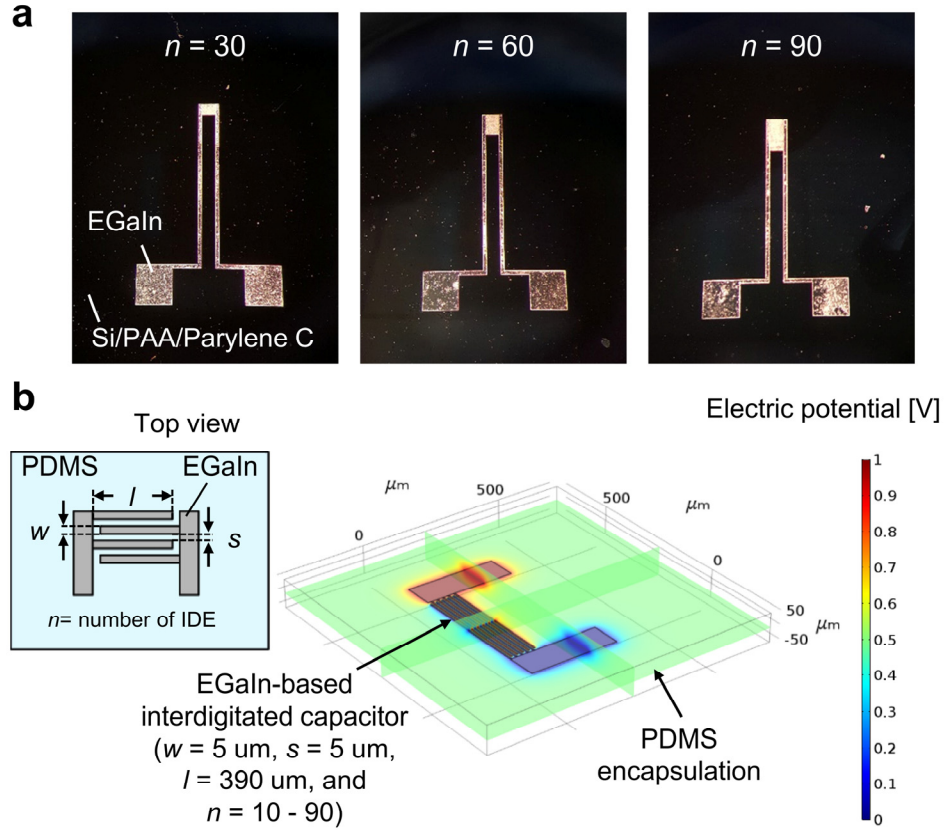
Supplementary Figure 2. Patterned EGaIn dot arrays. EGaIn dot array with dimensions of **a** 1 μm and **b** 500 nm.



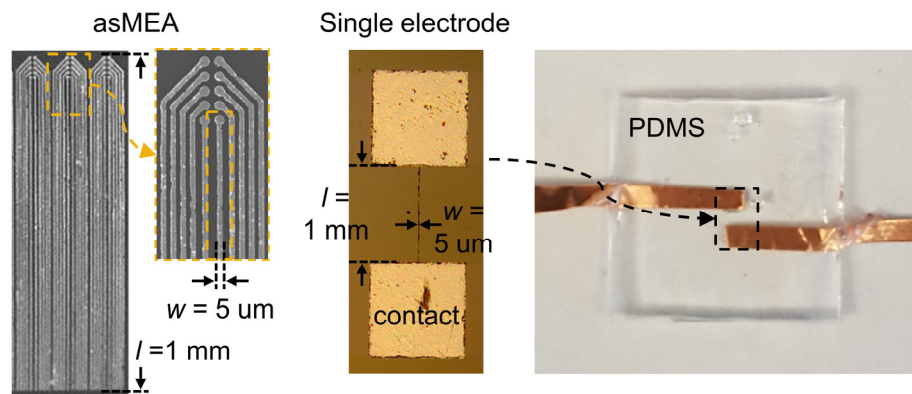
Supplementary Figure 3. Hybrid lithography process. **a** CAD design and **b** patterned EGaln nano/microstructures on Si wafer with detailed SEM images, including **c** test structures for line spacing, **d** square-shaped dot arrays, **e** electrical test structures for resolution characterization, and **f** resistor test structures with different line widths.



Supplementary Figure 4. Numerical evaluation of bending deformation of soft resistive sensor. **a** schematic of simulation model with applied boundary conditions²³ and **b** resulting finite element simulation of bending over a 10 mm radius circular cylinder along the length direction using COMSOL Multiphysics (COMSOL Inc., Burlington MA).



Supplementary Figure 5. Numerical evaluation of EGaIn-based interdigitated capacitor. **a** Fabricated EGaIn-based interdigitated capacitors with different number n of interdigitated electrodes (IDE). **b** Schematic of simulation model and simulated electric potential distribution for interdigitated capacitor with an applied voltage of 1 V using COMSOL Multiphysics (COMSOL Inc., Burlington MA).



Supplementary Figure 6. Fabricated all-soft microelectrode array. Fabricated microelectrode array with 100 electrodes and fabricated single electrode with same geometries (width (w) = 5 μm and length (l) = 1 mm) for bending and twisting tests.

Supplementary Table 1. Summary of EGaIn patterning methods using lithography-enabled, injection, additive, and subtractive processes and comparison with the proposed nanofabrication technique based on hybrid lithography.

Patterning Methods	Approach	Resolution (w)	Spacing (s)	Thickness (t)	Note
Lithography-enabled process	Hybrid lithography (This work)	180 nm	1 μm	300 nm - 1 μm	– Submicron-scale resolution – Thin-film fabrication – Complicated and multi-step process – Expensive fabrication
	Soft lithography: imprinting ²⁸ & reverse stamping ²⁹	2 μ m	1-2 μ m	< 2 μ m	– Micrometer-scale resolution – Thin-film fabrication – Uniform surface
	Additive stamping ³⁰	500 μ m	500 μ m	$\approx$ 1.5 μ m	– Simple and easy process – Large-area patterning > cm – Thin-film fabrication – Uniform surface
	Metal stencil film ³²	200 μ m	100 μ m	6-30 μ m	– Simple and high throughput process
	Microfabricated metal stencil film ²⁶	10 μ m	10 μ m	$\approx$ 2 μ m	– Relatively large feature size – Non-uniform thickness – Rough edges
	Photo Lithography ²⁷	20 μ m	40 μ m	$\approx$ 10 μ m	
Injection	Fluidic injection ³⁴	70 μ m	>70 μ m	70 μ m	– Simple, fast, and low-cost process
	Vacuum filling ³⁶	$\approx$ 10 μ m	-	> 50 μ m	– Uniform thickness, but requires high channel thickness
Additive process	2D printing ³⁷	$\approx$ 100 μ m	-	> 50 μ m	– 2D/3D structure fabrication
	3D printing ³⁸	$\approx$ 100 μ m	-	$\approx$ 100 μ m	– Relatively low resolution – Uniform thickness
	2D printing and transfer ³⁹	2 μ m	-	> 80 μ m	– Micrometer-scale resolution – Limited design – Complicated and multi-step process
Subtractive process	Laser ⁴⁰	4.5 μ m	100 μ m	< 1 μ m	– Micrometer-scale resolution – Serial process
	Electrochemical reduction ⁴⁴	$\approx$ mm	-	$\approx$ 120 μ m	– Inexpensive and facile process – Relatively low resolution – Non-uniform thickness