ADVANCED MATERIALS TECHNOLOGIES

Supporting Information

for *Adv. Mater. Technol.*, DOI: 10.1002/admt.201900158

Additive Manufacturing of 3D Structures Composed of Wood Materials

Doron Kam, Michael Layani, Sheer BarkaiMinerbi, Donna Orbaum, Shir Abrahami BenHarush, Oded Shoseyov, and Shlomo Magdassi**

WILEY-VCH

Supporting Information

Additive manufacturing of 3D structures composed of wood materials

Doron Kam, Michael Layani, Sheer Barkai Minerbi, Donna Orbaum, Shir Abrahami Ben Harush, Oded Shoseyov, & Shlomo Magdassi**

Table S1. Different approaches used to fabricate wood-based structures.

Technologies	Techniques	Fabrication approach	Unique properties
Molding	RT drying	Samples were left to dry at RT	High-density structure
	Freeze-casting	Mold samples formed on cold controlled stage followed by lyophilization	Aligned foam structure, low-density structure
Extrusion	DIW	Left to dry at RT, multiple extruders possible	High-density structure
	DCW	3D print onto a cold, controlled stage, followed by lyophilization	Aligned foam structure, low-density structure, thermal insulator
Inkjet	Drop on Demand (DoD) Inkjet	2D printing on a substrate	Patterned layer on a substrate
	Binder-jet	Inkjet printing of CNC/XG onto continuous layer of WF	Low-density structure and thermal insulator

Table S2. Ink compositions

Name	CNC [wt.%]	XG [wt.%]	WF [wt.%]	Ref
5% WF	9.1	0.075	5	DIW/DCW Fig S1-3
11.5% WF	8.5	0.069	11.5	
14.5% WF	8.2	0.067	14.5	
30% WF	6.7	0.055	30	
DW	0	0	20	Fig S9
0:1	1.2	0	20	
1:100	1.19	0.01	20	
1:10	1.18	0.02	20	
1:4	1.1	0.1	20	
3%	3	0.3	9	Fig S10
2%	2	0.2	9	
1%	1	0.1	9	
0.5%	0.5	0.05	9	
0.1%	0.1	0.01	9	
Pine CNC-LAB	3.5	0.07	11.5	DIW/DCW Fig S11
Maple CNC-LAB	3.5	0.07	11.5	
75 CNC-LAB	3.5	0.07	11.5	
Pine CNC-CF	8.2	0.07	11.5	DIW/DCW Fig S12
Maple CNC-CF	8.2	0.07	11.5	

Name	CNC [wt.%]	XG [wt.%]	BYK 348 [wt.%]	Ref
Inkjet-CNC	1.5	0	0	Inkjet
Binder-CNC	1.5	0	0.011	Binder jet Fig S13
Binder-XG	0	0.1	0.01	

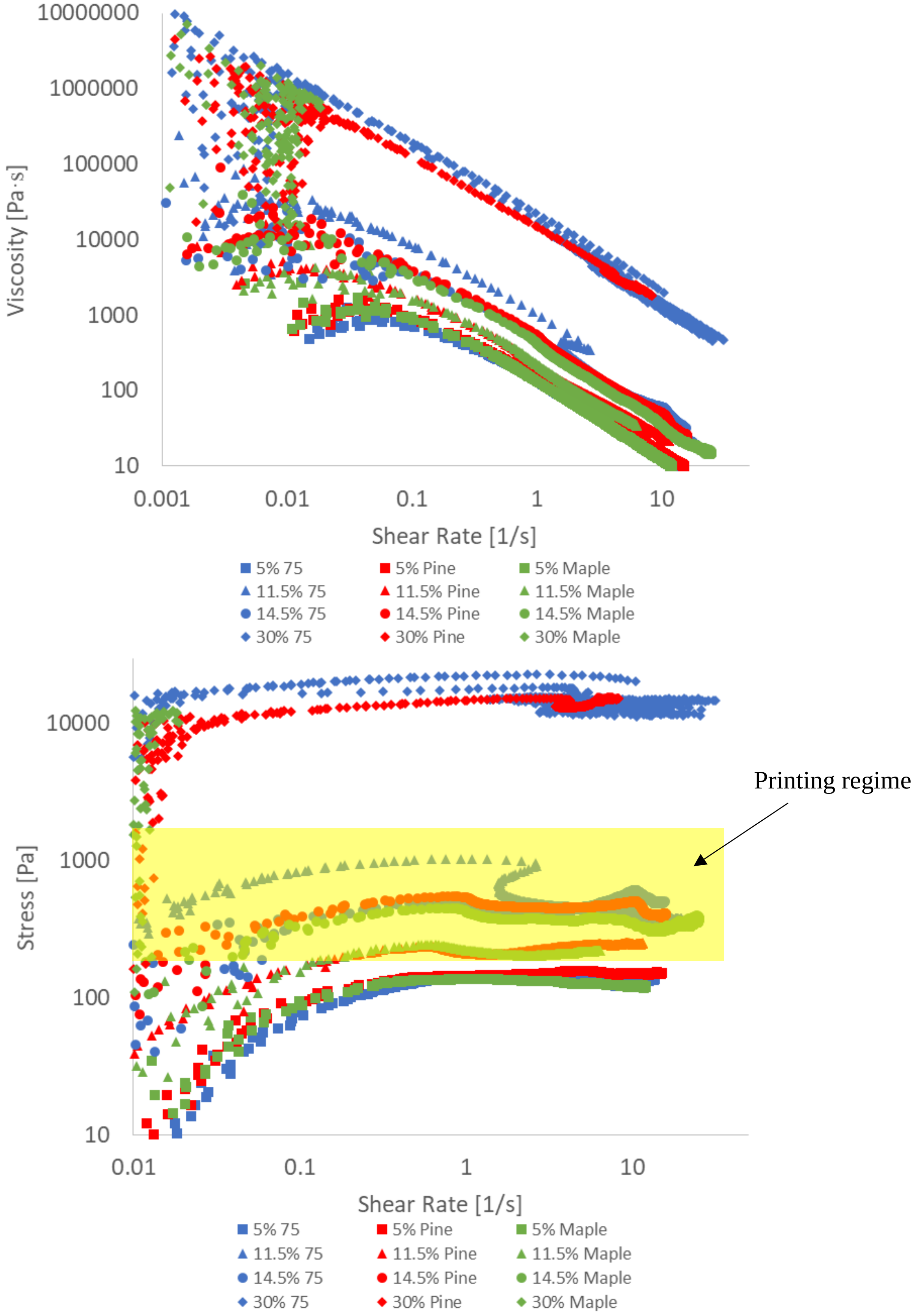
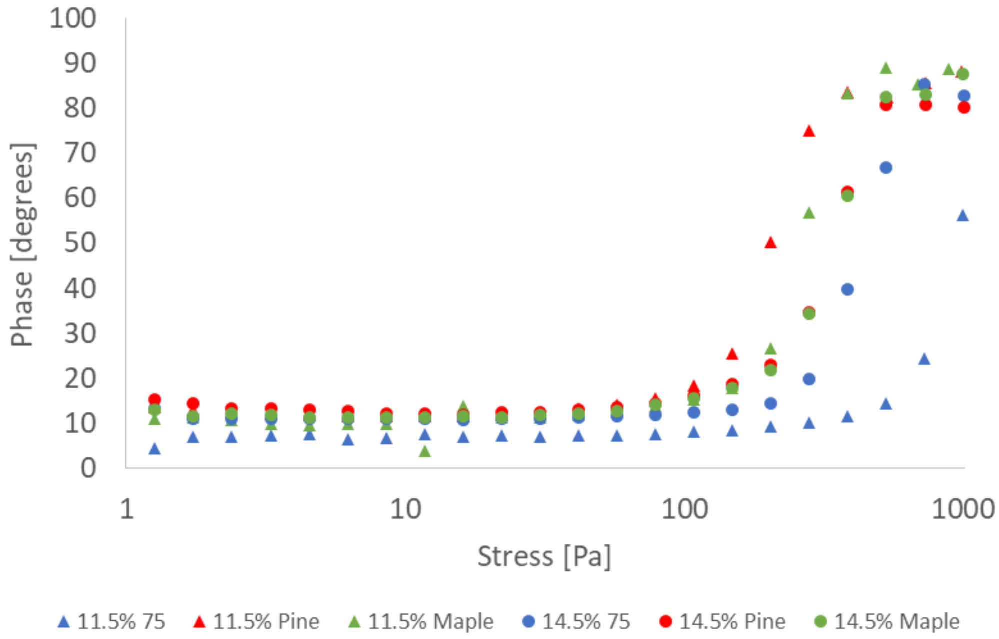


Figure S1.
Rheology measurements of inks containing different concentration of WF (75, Pine, Maple) while the XG:CNC (1:122) ratio was kept constant. (**Top**) All inks exhibiting shear thinning behavior are presented, as are (**Bottom**) unprintable inks (too liquid or too viscous).



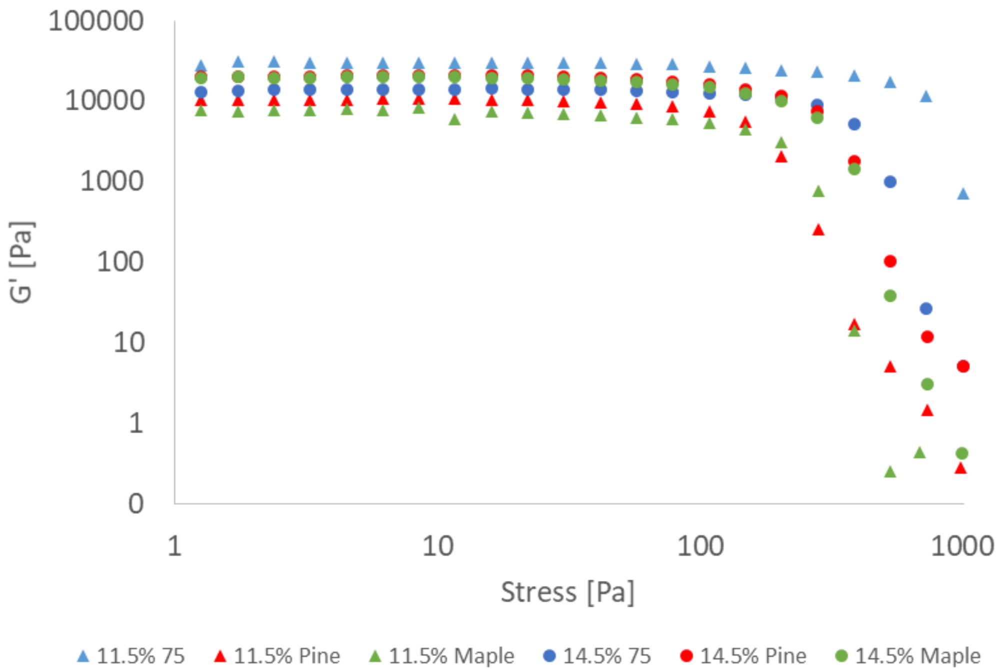


Figure S2.
Oscillation stress sweep of printable inks at f=1Hz. (**Top**) Low phase angles indicate “solid-like” behavior while high phase angles indicate “liquid-like” behavior. (**Bottom**) Storage modulus indicating linear visco-elastic region up to ~100 Pa.

Table S3. Yield stress point (flow point) derived from oscillation stress sweep.

% WF	WF source	Yield stress point [Pa]
	75	904
11.5%	Pine	200
	Maple	263
	75	414
14.5%	Pine	309
	Maple	336

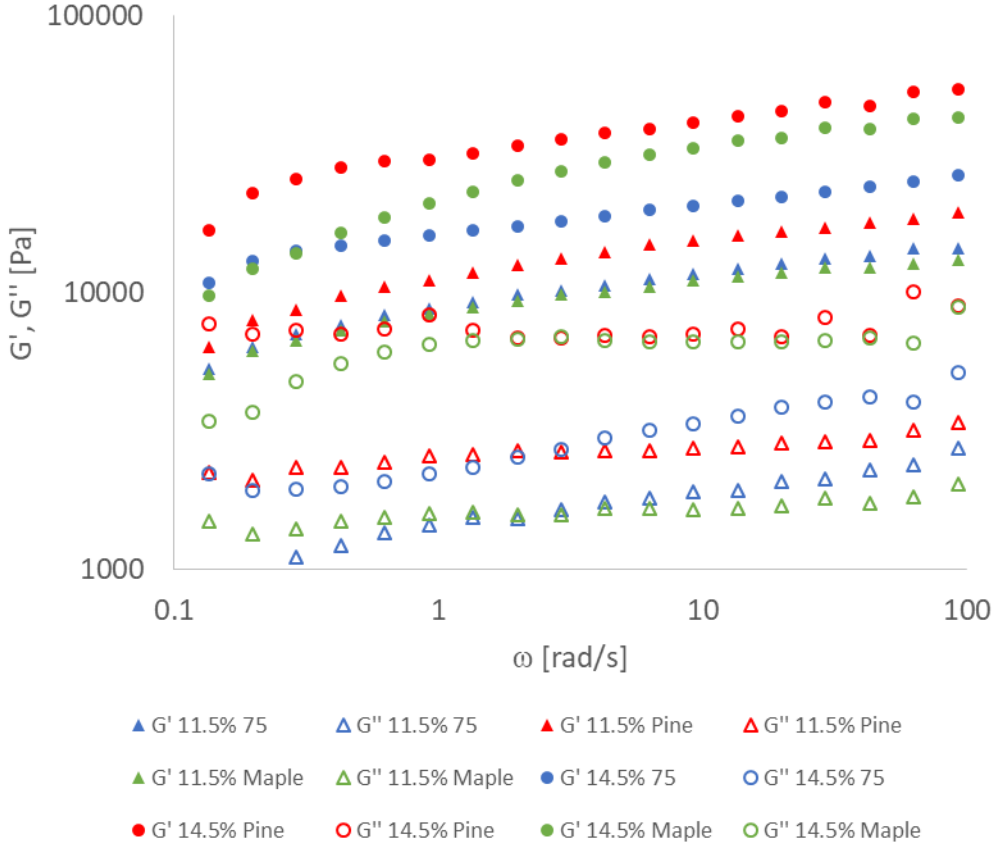


Figure S3.
Oscillation frequency sweep of printable inks at τ=10Pa.

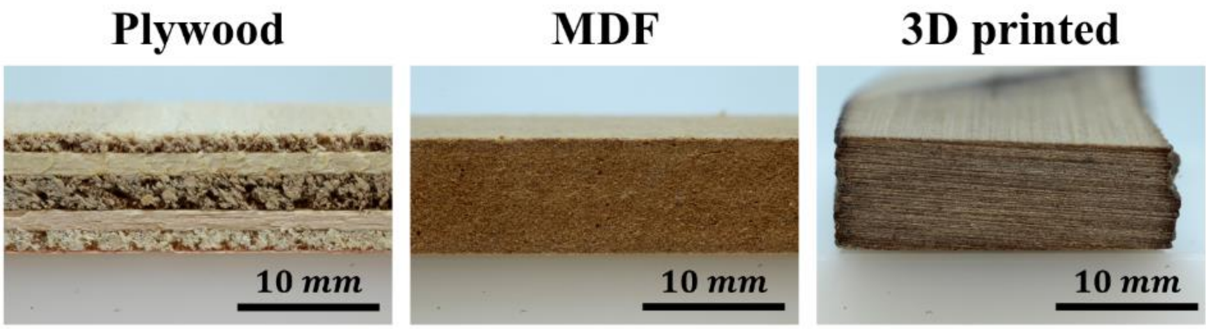


Figure S4.
Cross-section images of engineered woods and a 3D-printed wood-based sample (DIW).

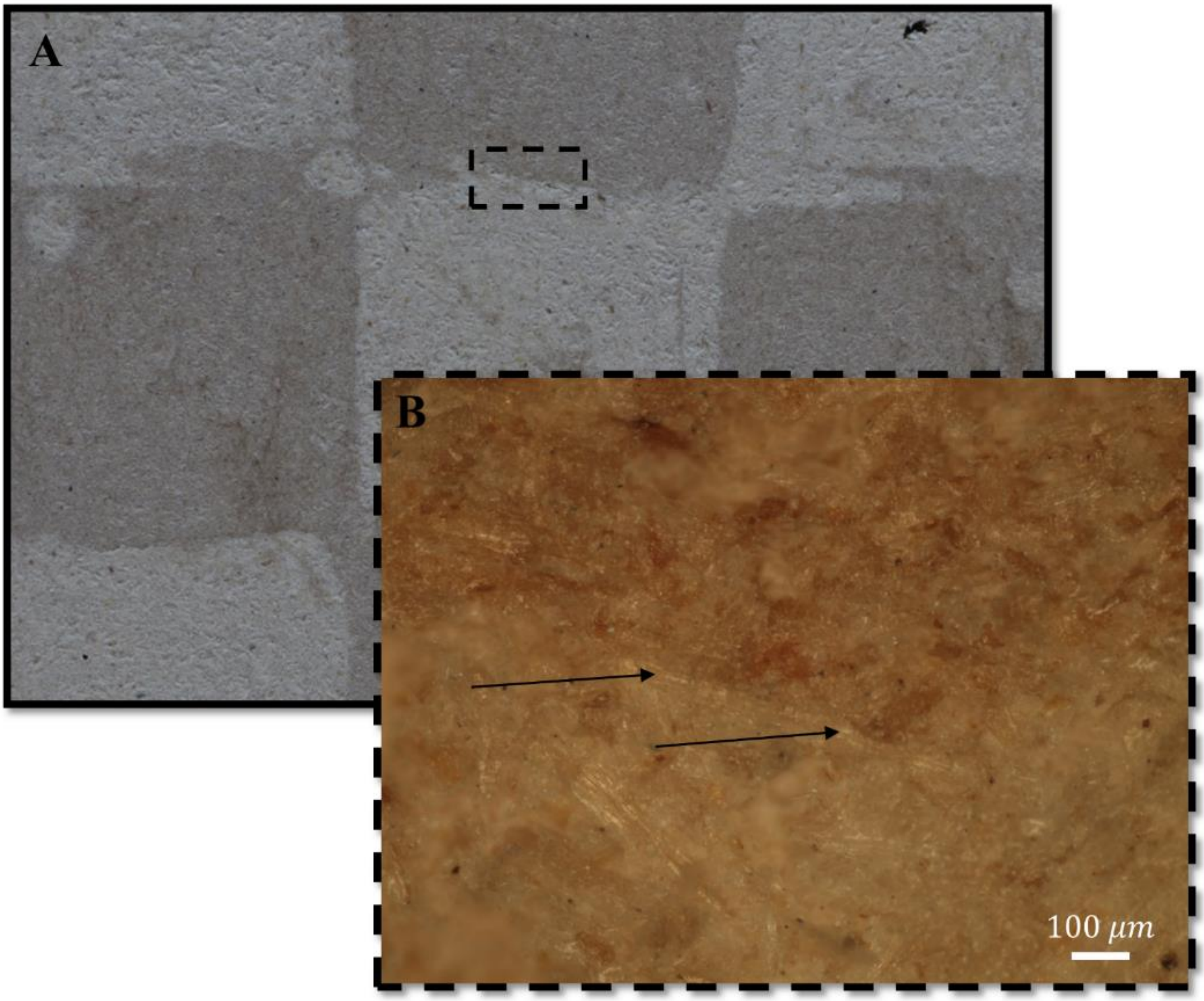


Figure S5.

Close-up photo of Fig 1C, 3D DIW printing of multi-material. (**A**) Image showing final printed structure and (**B**) microscopy image showing smooth bonding between the two types of wood.

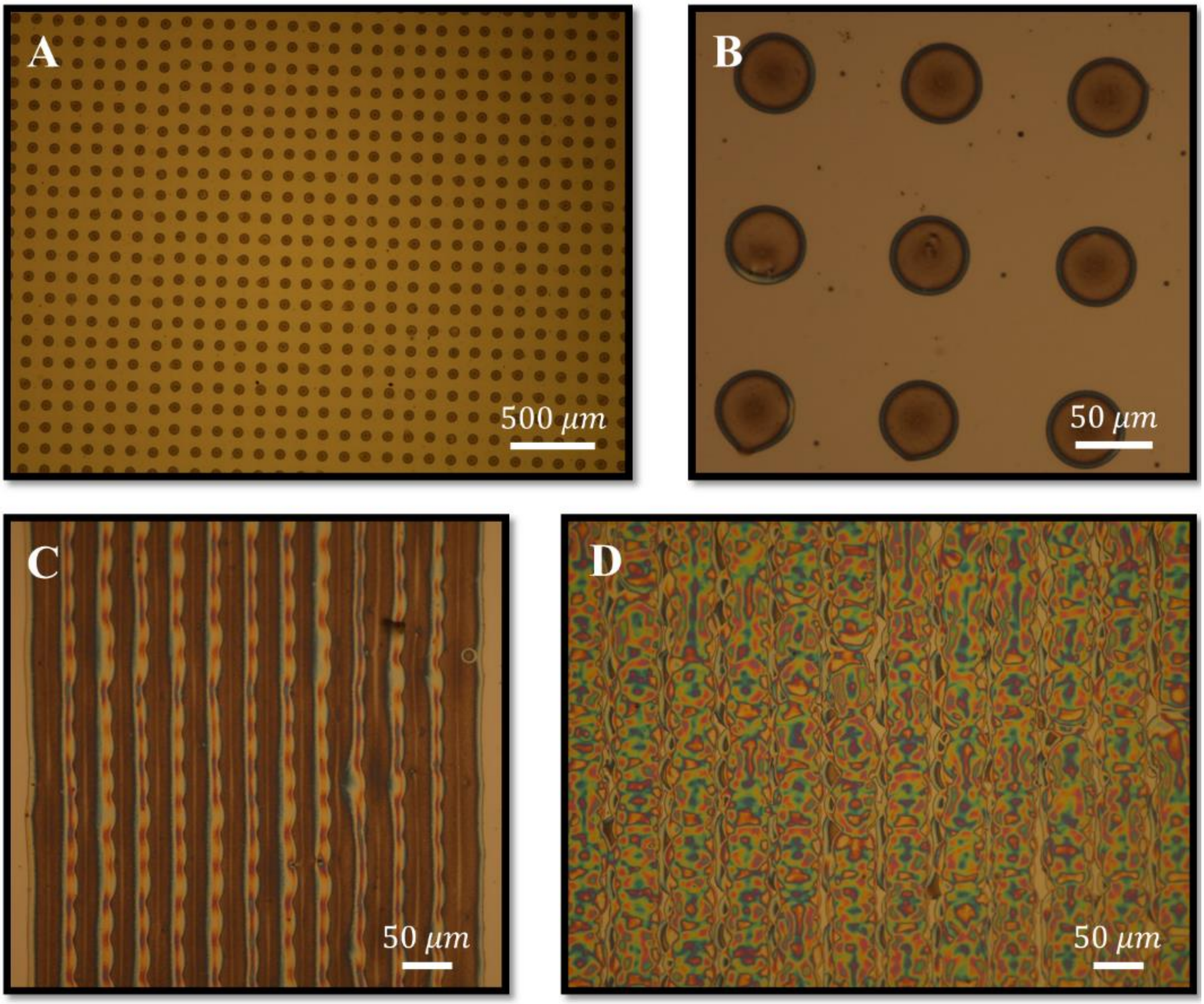


Figure S6.

Microscopy images of CNC-CF ink jet drops and patterns printed on a silicon wafer: **(A,B)** 200 dpi, (**C**) 1 layer at 600 dpi and (**D**) 5 layers at 600 dpi.

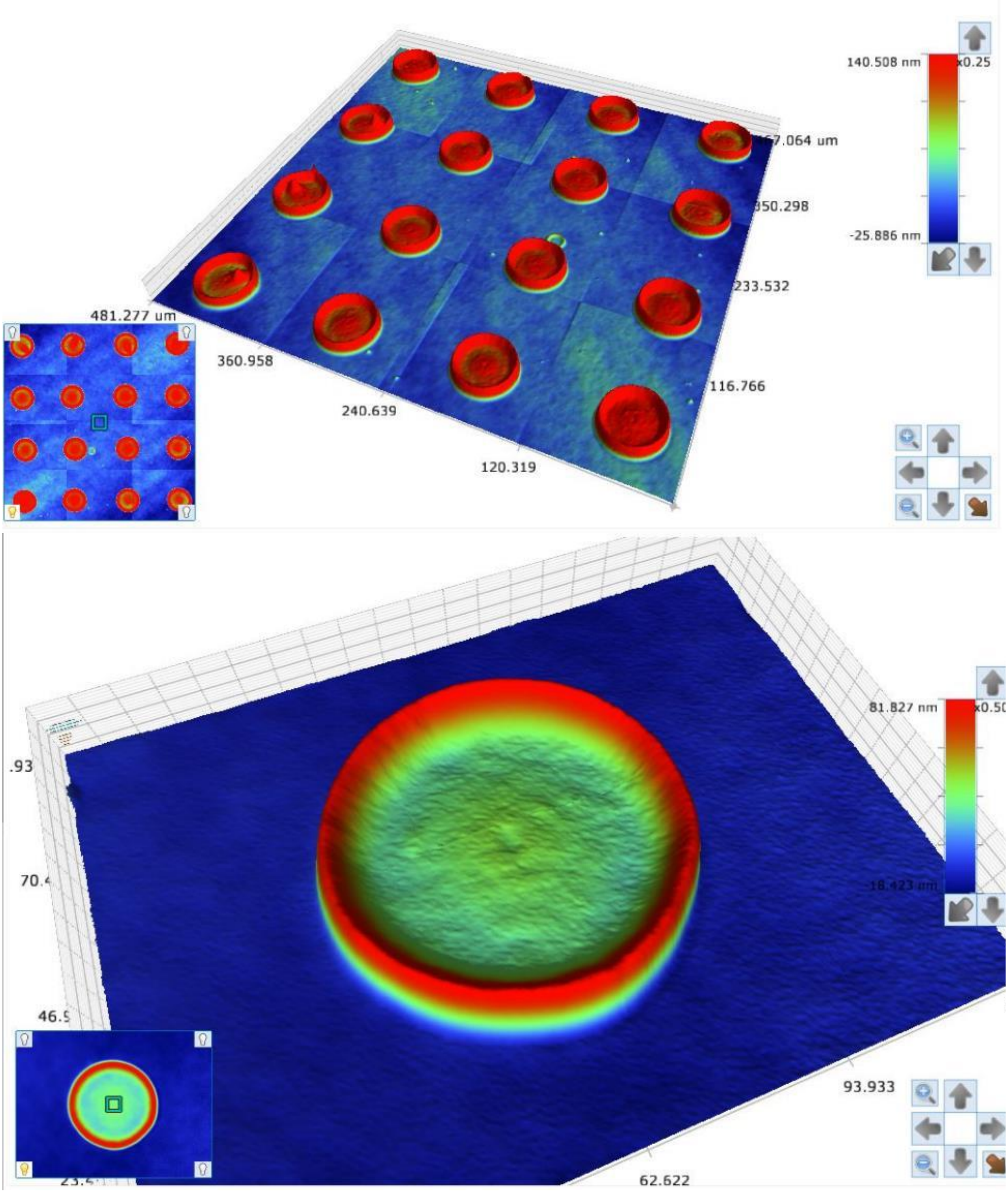


Figure S7.

Optical profile measurements of CNC-CF ink jet drops on a silicon wafer substrate at (**Top**) 200 dpi, showing uniformity reproducibility of droplets. (**Bottom**) Morphology measurements of a single drop: diameter of 55 μm and height of 40um at the center of the droplet and height of coffee ring effect edge was 75 nm.

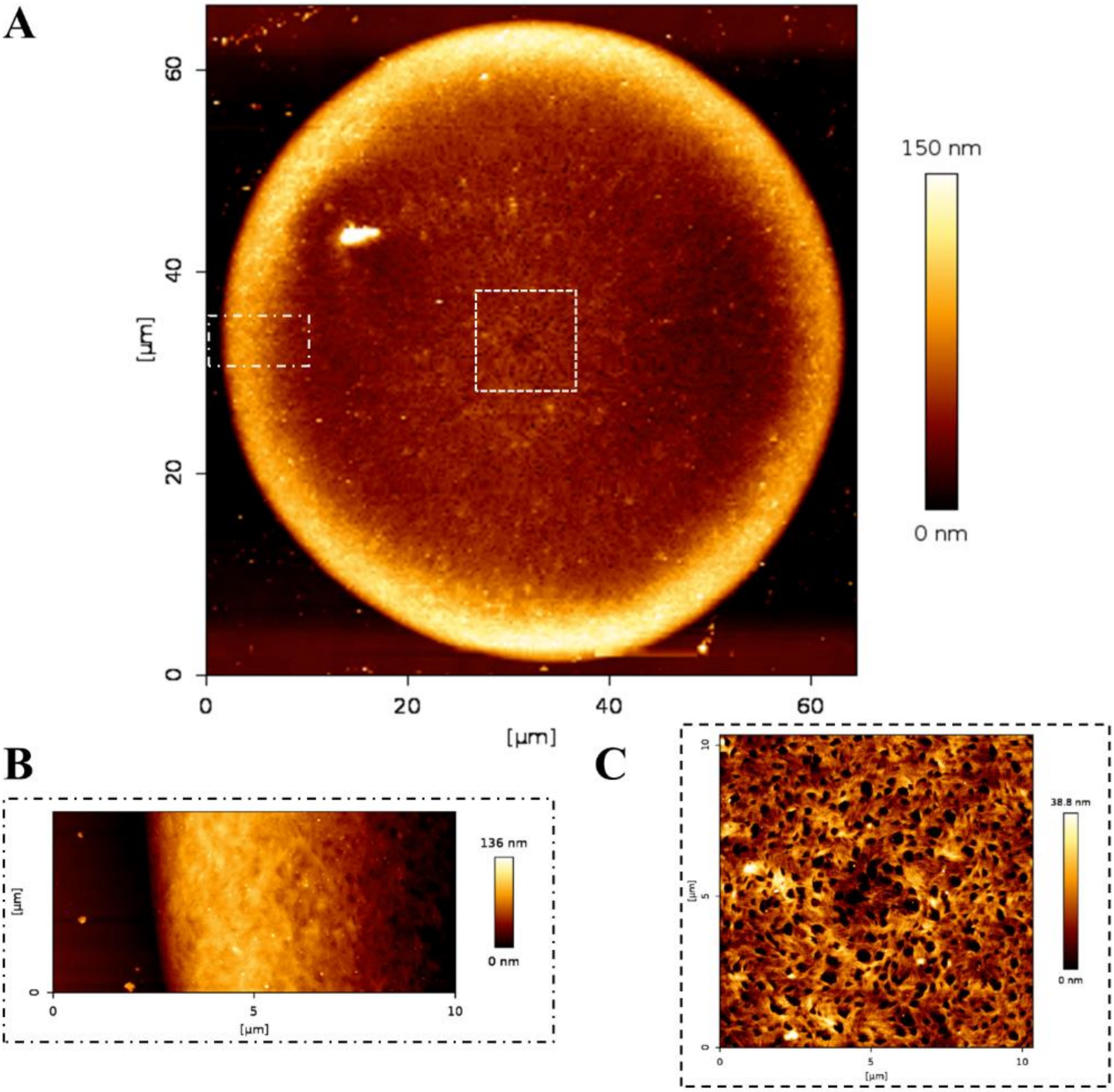


Figure S8.
(A) AFM image of a single CNC-CF ink jet drop on a silicon wafer substrate (**B**-**C**) zoom-in measurements.

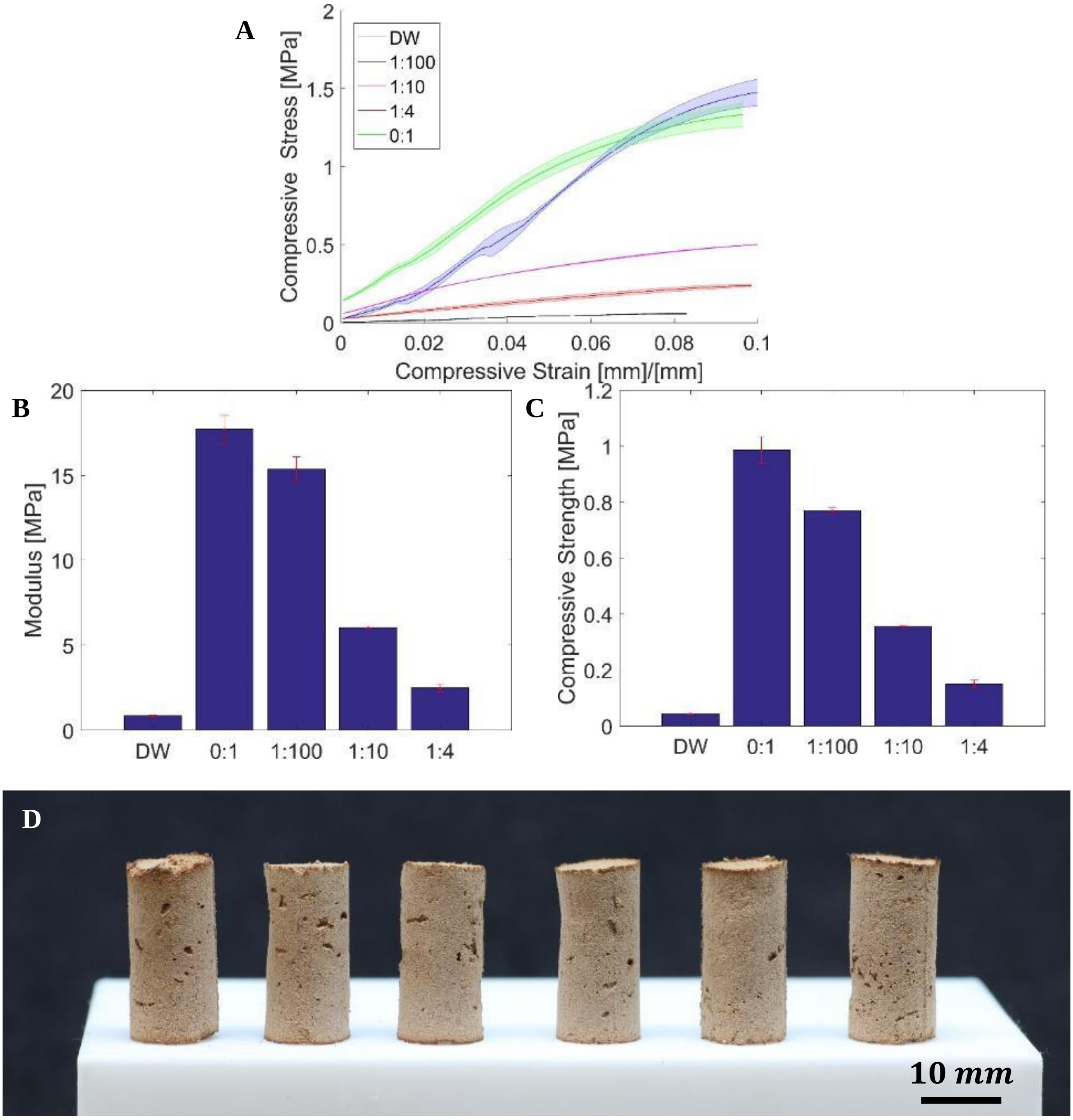


Figure S9.

(**A**) Stress-strain curves and (**B-C**) modulus and compressive strength derived from compression testing of Eucalyptus mold samples at different XG:CNC ratios (Table S2). (**D**) Photograph of molded wood samples.

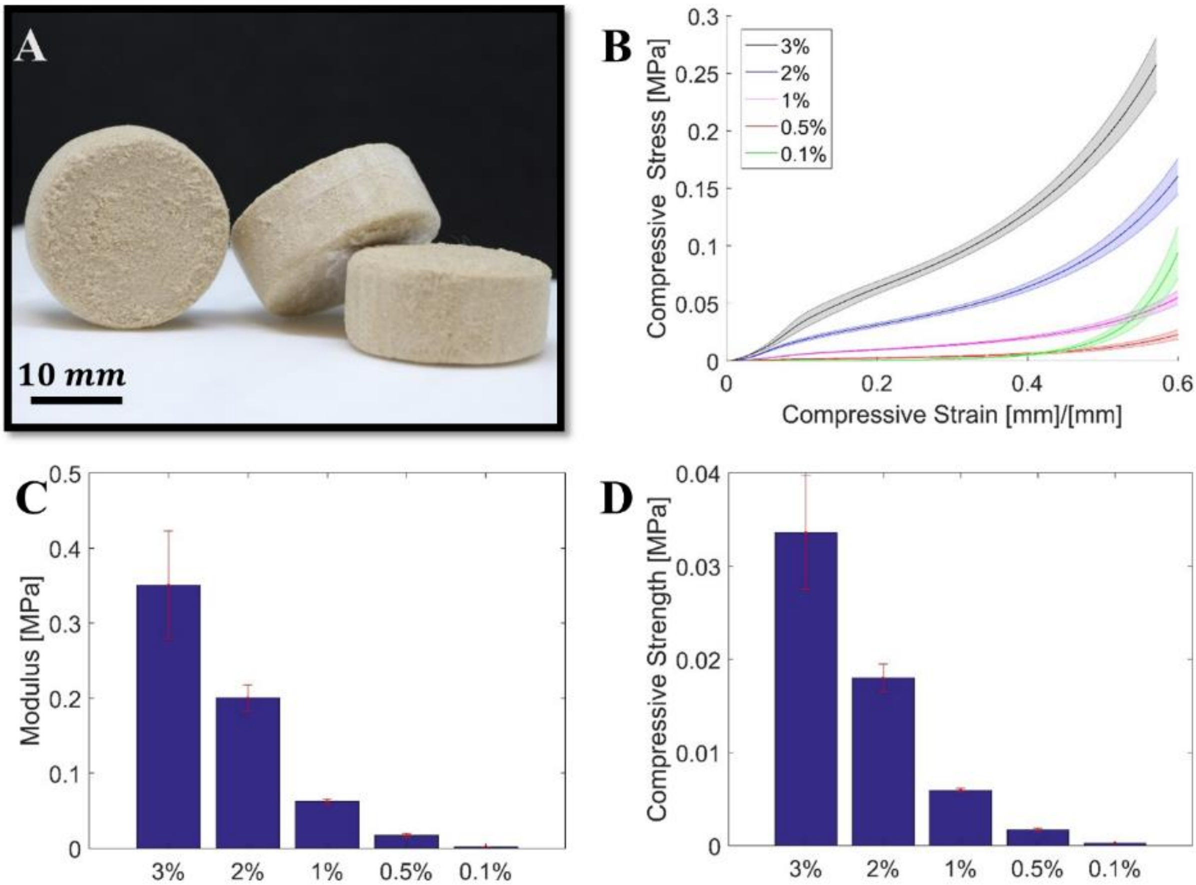


Figure S10.
(**A**) Photograph of freeze-cast molded wood foam samples. (**B**) Stress-strain curves and (**C-D**) modulus and compressive strength of samples prepared from inks with different binder:WF ratios, all containing a 1:10 XG:CNC ratio (Table S2).

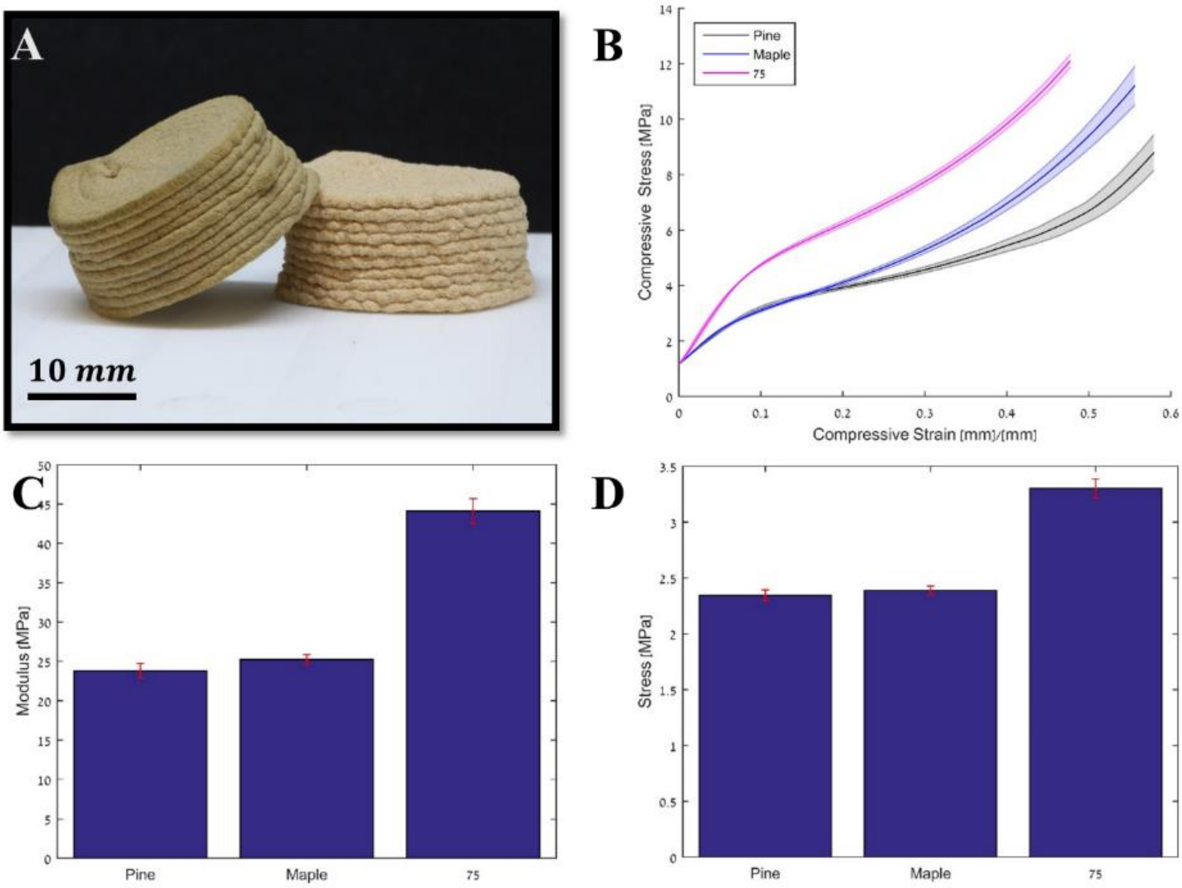


Figure S11.
(**A**) Photograph of printed samples (left: '75'; right: 'maple') (**B**) Stress-strain curves and (**C-D**) modulus and compressive strength derived from compression tests of wood DIW-printed with ink comprised of CNC-LAB and different concentrations of WF (Table S2).

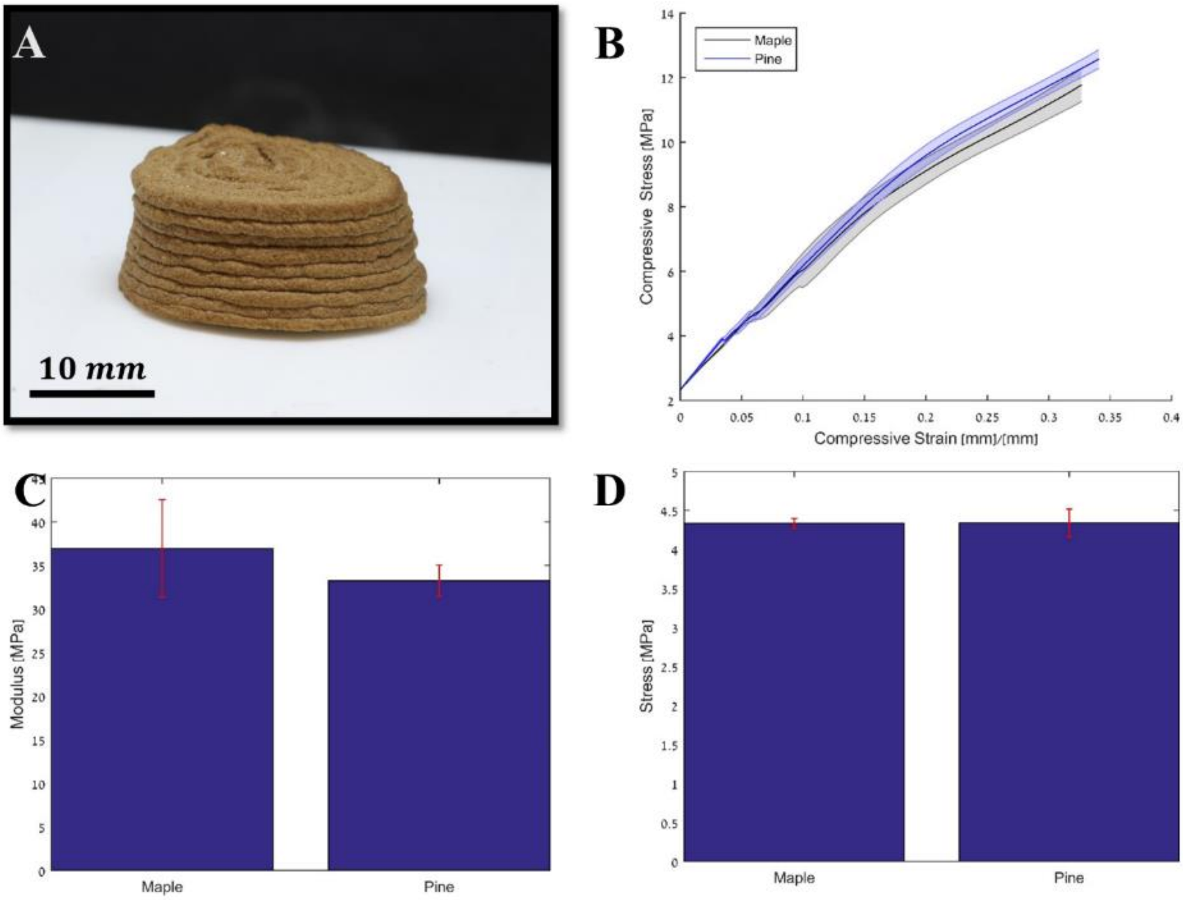


Figure S12.

(**A**) Photograph of DIW printed samples (**B**) Stress-strain curves and (**C**-**D**) modulus and compressive strength derived from compression tests performed on wood DIW-printed with ink comprised of CNC-CF and different concentrations of WF (Table S2).

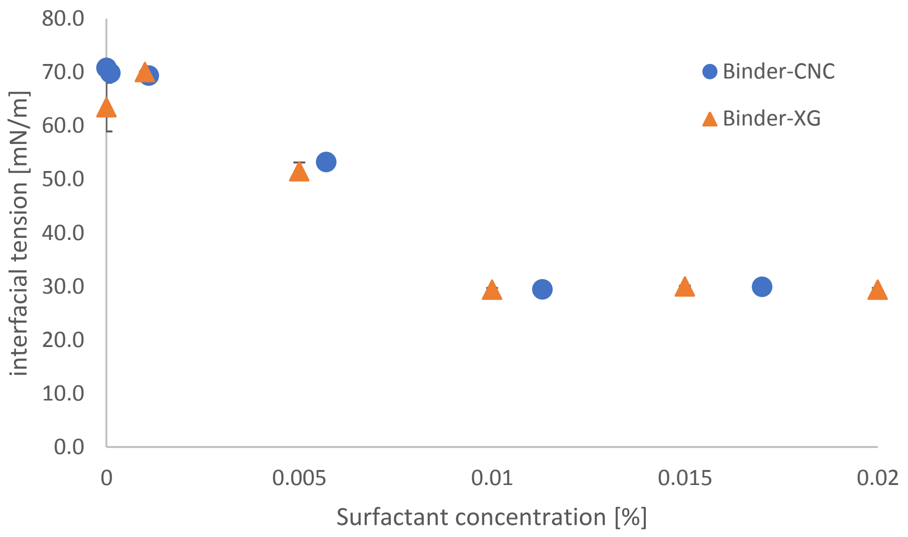


Figure S13.
Dependence of surface tension on surfactant concentration in Binder-CNC and Binder-XG inks (Table S2).