Electronic Supplementary Material (ESI) for Lab on a Chip.

Supplementary Information

Simple Modification to Allow High-Efficiency and High-Resolution Multi-Material 3D-Printing Fabrication of Microfluidic Devices

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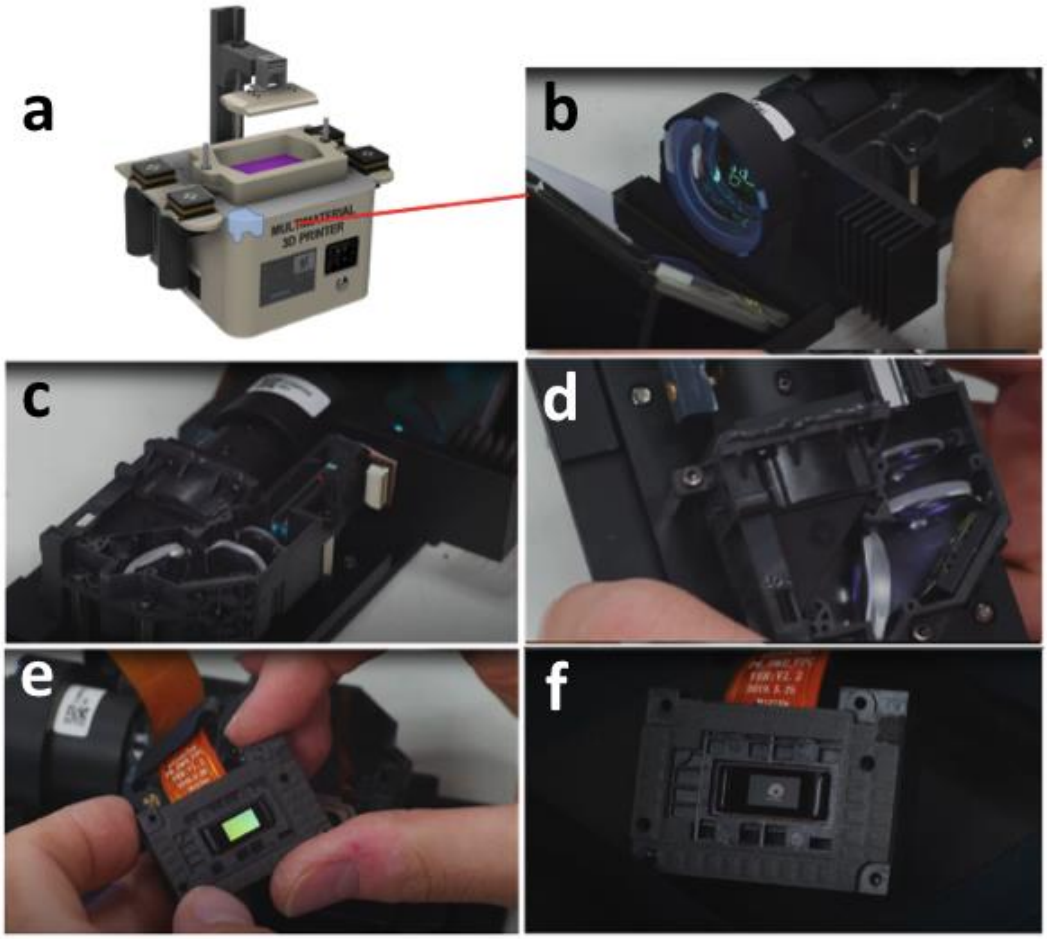


Figure SI1 - Position of the DLP projector* and details of its construction. (a) Position on the printer case. (b) Projection len and mirror. (c-d) Details of the internal optics. (e-f) Detail of the digital micromirror device (DMD). In (f) is projected the logotype of the State Univesity of Campinas (UNICAMP).

*__PDC07__ light engine inside DLP 660te UHD DMD chipset, which is well suited for professional industrial 3D printer, the kit projection optical system have been optimized from 385nm to 405nm wavelength especially; use all glass lens and metallic body material to meet the industrial device requirement; also, several type of projection lens optionally could match with the projection optical system to meet the different printing image; Developers can easily manage the light power, create, store, through an easy-to-use graphical user interface from development platform.
Features

- 1. Hight resolution 3840*2160
- 2. Instant LED on/off.
- 3. Dedicated for UV Lithography application.
- 4. Excellent optical performance
- 5. Easy installation to multiple unit integration
- 6.Common software platform : PDC05/PDC06/PDC07

(Manufacturer information)

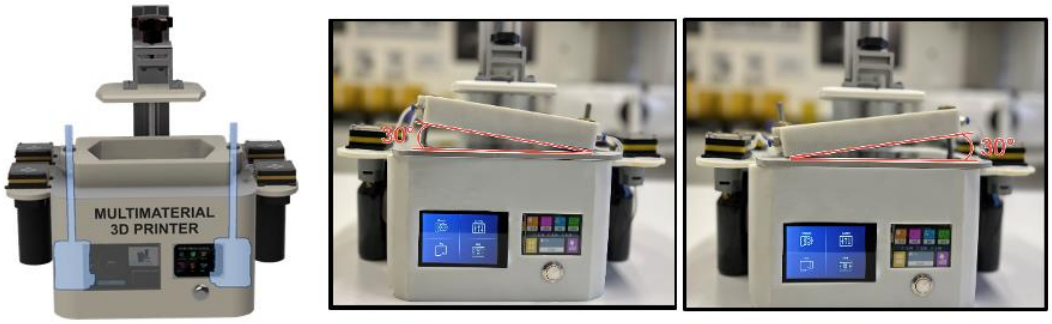


Figure SI2 - Position of the two stepper motors and vat inclination system.

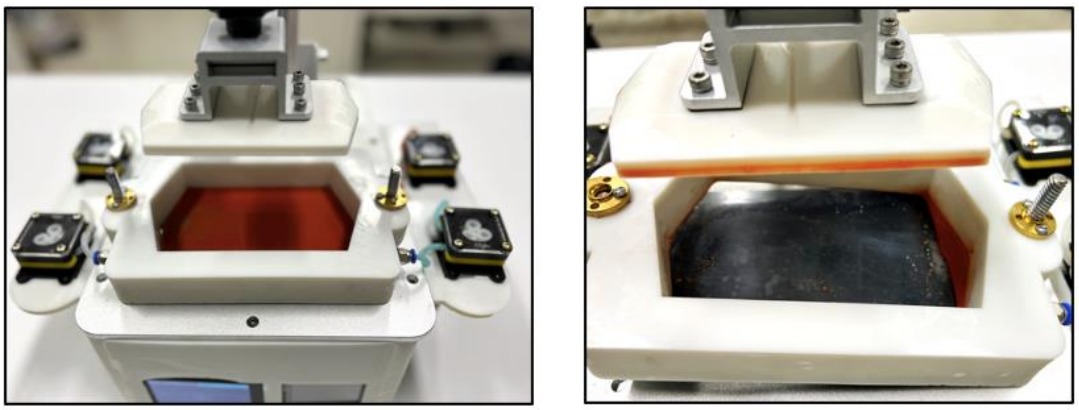


Figure SI3 - Resin being withdraw back to the source reservoir.

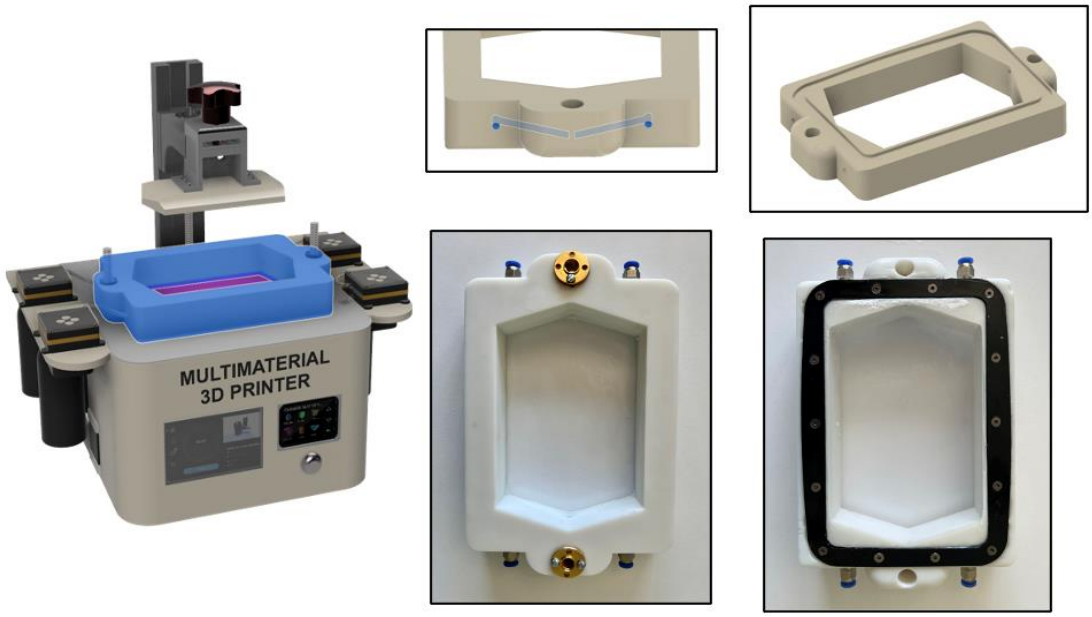


Figure SI4 - Vat design and printed part.

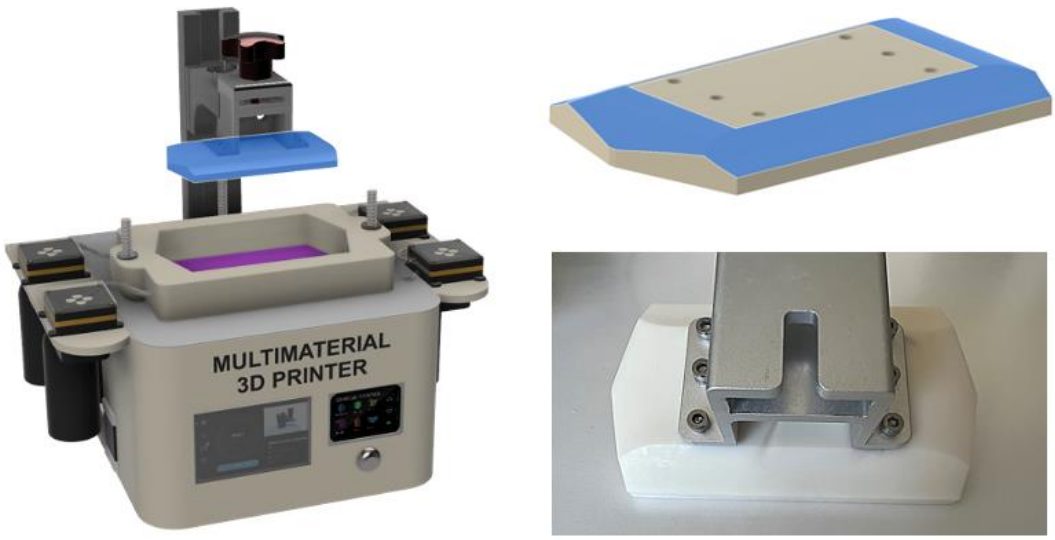
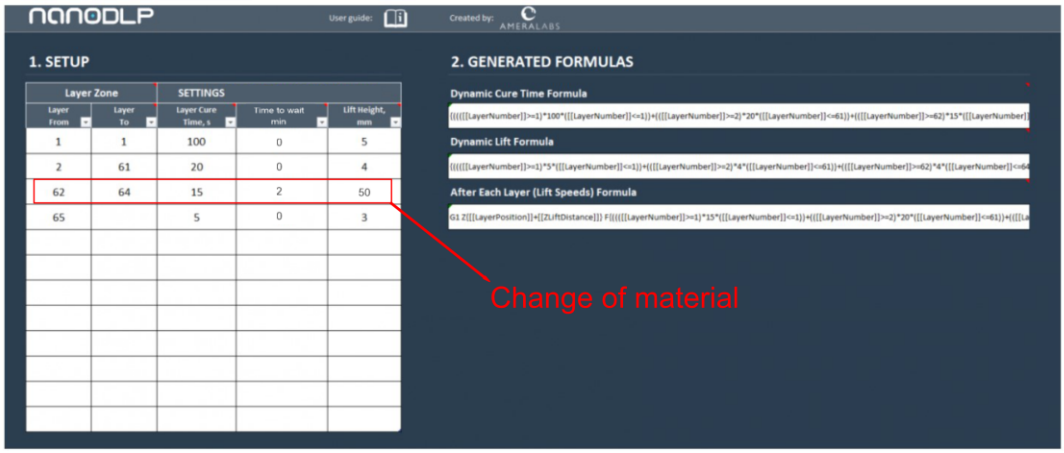


Figure SI5 – Print platform design with chamfered perimeter design for easy resin cleaning when changing materials.


Dynamic Calculation
Dynamic Cure Time Second
{(((([[LayerNumber]]>=1)*100*
([[LayerNumber]]<=1))+
((([[LayerNumber]]>=2)*20*
([[LayerNumber]]<=61))+
((([[LayerNumber]]>=62)*15*
([[LayerNumber]]<=64))+
Dynamic Speed µmSecond
{(((([Stop]]>=60s))*100*)
Dynamic Lift Millimeter
{(((([[LayerNumber]]>=1)*5*
([[LayerNumber]]<=1))+
((([[LayerNumber]]>=2)*4*
([[LayerNumber]]<=61))+
((([[LayerNumber]]>=62)*4*
([[LayerNumber]]<=64))+


nanoDLP
User guide:
Created by:
AMERALABS
1. SETUP
Layer Zone
SETTINGS
Layer From
Layer To
Layer Cure Time, s
Time to wait min
Lift Height, mm
1 1 100 0 5
2 61 20 0 4
62 64 15 2 50
65 5 0 3
2. GENERATED FORMULAS
Dynamic Cure Time Formula
Dynamic Lift Formula
After Each Layer (Lift Speeds) Formula
Change of material

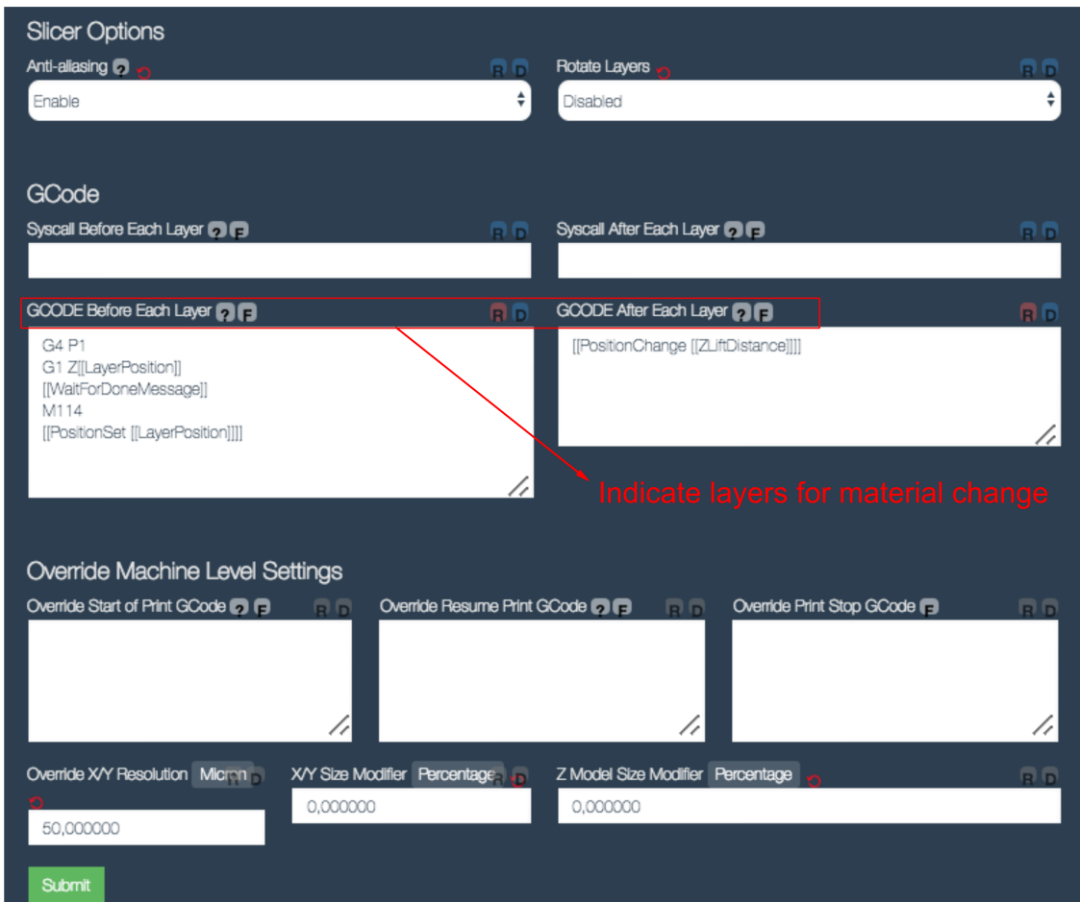

Slicer Options
Anti-aliasing
Enable
Rotate Layers
Disabled
GCode
Syscall Before Each Layer
Syscall After Each Layer
GCODE Before Each Layer
G4 P1
G1 Z[[LayerPosition]]
[[WaitForDoneMessage]]
M114
[[PositionSet [[LayerPosition]]]]
GCODE After Each Layer
[[PositionChange [[ZLiftDistance]]]]
Indicate layers for material change
Override Machine Level Settings
Override Start of Print GCode
Override Resume Print GCode
Override Print Stop GCode
Override X/Y Resolution Micron
50,000000
X/Y Size Modifier Percentage
0,000000
Z Model Size Modifier Percentage
0,000000
Submit

Figure SI6 – G-code generated for multi-material printing of the object using the NanoDLP software.

```
G-Code_UNICAMP_GEM03

**G-Code - Bootup :**



**G-Code - Start Of Print:**

$X ; Unlock GRBL in case we're in an alarm state
G90 ; Put GRBL in absolute mode
$H ; Home GRBL so we can start from a known place
G4 P0.1 ; SolidRay movement sync
[[WaitForDoneMessage]] ; Wait done message
G92 X0 Y0 Z0 ; Set our new homed position as the origin
[[PositionSet 0]] ; Set the current position as 0 in NanoDLP

**G-Code - Before Each Layer:**

G01 Z[[LayerPosition]] F100 ; Move to the correct layer height
G4 P0.1 ; SolidRay movement sync
[[WaitForDoneMessage]] ; Wait done message
[[PositionSet [[LayerPosition]]]] ; Save the current position in NanoDLP

**G-Code - After XX Layer:**

[[Delay 1]] ; Wait 1 second for the resin to “settle”
G01 Z{[[LayerPosition]] + [[ZLiftDistance]]} F100 ; Indicate the position that the
platform must go up to change material
G4 P0.1 ; Here must be added the code for material exchange
[[WaitForDoneMessage]] ; Wait done message. You can put a message on the panel
warning the change of material or a sound beep.
[[Delay 120]] ; Wait 120 seconds. Put the time for material exchange for the resin.
[[PositionChange [[ZLiftDistance]]]] ; Indicate the position that the platform must
lower to change material.

**G-Code - End Of Print:**

$X ; Unlock GRBL just in case
G01 Z0 F100 ; Bring the platform above the resin level


**G-Code - Resume Print:**

$X ; Unlock GRBL in case we're in an alarm state
G90 ; Put positioning in absolute mode
G92 Z[[CurrentPosition]] Y0 X0 ; System crashed so we need to recover current
position from NanoDLP and set it in GRBL
G1 Z[[LayerPosition]] F100; Move to layer position
G4 P0.1 ; SolidRay movement sync
[[WaitForDoneMessage]] ; Wait done message
```

Figure SI7 - Manual editing of G-code using Monkeyprint software as controller.

Software, Firmware and files: LINK DRIVE

G-Codes on-line editor: LINK GITHUB

Figure SI8 – Parts list for adaptation of Nova3D Bene6 printer 2021 version.

Figure SI9 – Parts list for adaptation of Anycubic DLP D2 printer 2022 version.

Table SI1 – Characteristics of the DLP projector (manufacturer information).

Model

NO	Production name	Printing Resolution	Image@Work distance	Optical distortion	wavelength
1	PDC07-30	28-35um	115.2*64.8@158	0.10%	405/385

Specifications

Display technique	TI DLP 0.66-inch 4K UHD DMD
Resolution	3840*2160 XPR
Light source	LED UV405/385nm
Light channel	Single channel
Optical power	5.5W@120W
Offset	Without offset
Contrast	1200:1
Uniformity	>92%
Power supply	AC110V~240V，50/60HZ, DC12V/7A
Total power	<120W
Dimension	L325*W272*H160mm
interface	DCIN
	HDMI-TYPEA
	miniUSB

Table SI2 - Additional data on the resins used

Resin	Composition/Modification	Feature/application	Viscosity (cps at 25 °C)	Tensile strength (MPa)
GEM 1[a]	See note below	Rigid-clear	176 ± 30	38 ± 8
GEM C1[a]	PEDOT:PSS	Conductive	484 ± 30	54 ± 7
GEM C2[a]	3D-ADD CuEK1	Conductive	375 ± 40	48 ± 12
GEM 2[a]	GEM 1 with blue fluorescent pigment XUK473/3019	Fluorescent	198 ± 20	42 ± 8
GEM 3[a]	GEM 1 with fluorophore pigment TEXWUJJJ	Phosphorescent	234 ± 30	40 ± 10
Siraya Fast	Pigmented with dyes	Colored resins	100 [b]	33 [b]
3Dresyn IM-HT-WS	Commercial - unmodified	Water-soluble	<100 [b]	>40 [b]
Siraya Blu	Commercial - unmodified	Rigid-clear	700 [b]	50 [b]
Siraya Tenacious	Commercial - unmodified	Flexible	500 [b]	24 [b]

[a] Manufactured resin: GEM 1: Oligomer: 39.8% Ebecryl 8210 and 39.8% Sartomer SR 494. Reactive diluente: 19.8%, genomer 1122. Photoinitiator: 0.4%, 2,4,6 Trimethylbenzoyl-diphenyl-phosphineoxide (TPO) and UV blocker, 0.2 %: 2,2'-(2,5-thiophenediyl)bis(5-tert-butylbenzoxazole) (OB+).

GEM C1: GEM 1 with poly(3,4-Ethylenedioxythiophene)-polystyrenesulfonate (PEDOT:PSS).

GEM C2: GEM 1 with 3D-ADD CuEK1.

[b] Provided by the manufacturer.