

U-STUDIO

User manual



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Contents

I. GETTING STARTED	2
A. U-STUDIO Settings Files	2
1. Printer Settings Files	2
2. Material Settings Files	2
B. U-STUDIO Files	2
1. Calibration Files	2
2. Layer-Based Printing Files	3
3. Model-Based Printing Files	3
II. WELCOME WINDOW	4
A. Single-Layer Calibration	4
B. Multi-Layer Calibration	4
C. Layer-Based Printing	4
D. Model-Based Printing	5
E. Recents	5
F. Examples	5
III. MAIN WINDOW	6
A. Menu Bar	6
1. File	6
2. Edit	7
3. Hardware	7
4. View	15
5. Settings	15
6. Window	17
7. Help	20
B. Icon Bar	21
C1. Workflow UI – Single-Layer Calibration	22
1. Preparing Tab	23
2. Parameter Settings Tab	25
3. Printing Tab	30
4. Finalizing Tab	32
C2. Workflow UI – Multi-Layer Calibration	33
1. Preparing Tab	34
2. Parameter Settings Tab	36
3. Printing Tab	41
4. Finalizing Tab	43
C3. Workflow UI – Layer-Based Printing	44
1. Preparing Tab	45
2. Layer Tab	47
3. Printing Tab	51
4. Finalizing Tab	53
C4. Workflow UI – Model-based printing	54
1. Preparing Tab	55
2. Modeling Tab	57
3. Parameter Settings Tab	60
4. Printing Tab	62
5. Finalizing Tab	64
D. Model Viewer	65
E. Version history	68

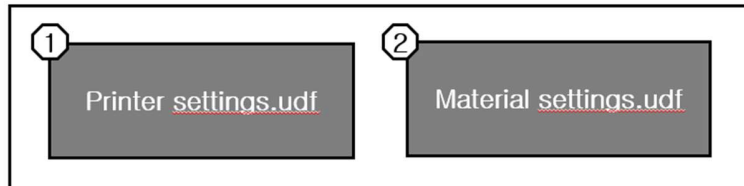
I. Getting Started

U-STUDIO is a bundled software program that allows the user to effectively utilize the various bio printing functions of the U-FAB. Typically, the user first performs Single- or Multi-Layer Calibration to identify optimal dispensing parameters to print various biomaterials in 3-dimensional (3D) form. The program then utilizes the parameters set during calibration for the actual 3D printing.

The following explain the files used in the U-STUDIO program.

A. U-STUDIO Settings Files

The U-STUDIO Settings Files include Printer Settings Files and Material Settings Files.



1. Printer Settings Files

Users can choose the parameters pertaining to general printing operations such as the filament flowrate, Whether to Use Nebulizer, and the speed of the Build-plate. This information is saved as a Printer settings.udf file. More on this at Section III.-A.-3.-[\[f. Printer Settings\]](#)

2. Material Settings Files

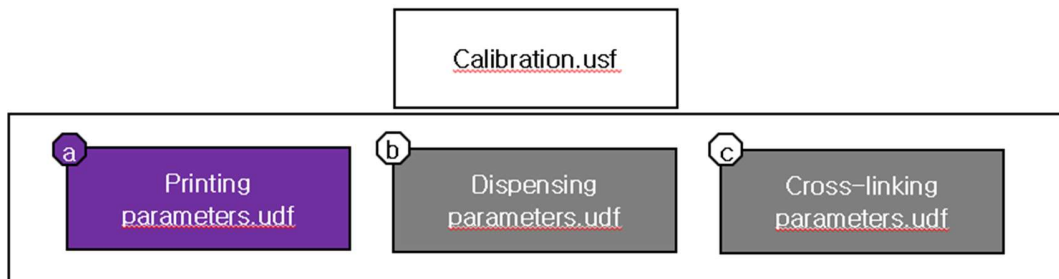
Users can adjust the information for each material to be used and save this information as a Material settings.udf file. More on this at Section III.-A.-5.-[\[b. Material Settings\]](#).

B. U-STUDIO Files

The U-STUDIO Files are categorized as the Calibration Files and Printing Files.

1. Calibration Files

The Calibration Files include the User data files listed below.



a. Printing Parameters

Users can adjust the parameters regarding the Printing shape and save them as a Printing parameters.udf file. More on this at Section III.-C1.-2.-[\[a. Printing Parameters\]](#).

b. Dispensing Parameters

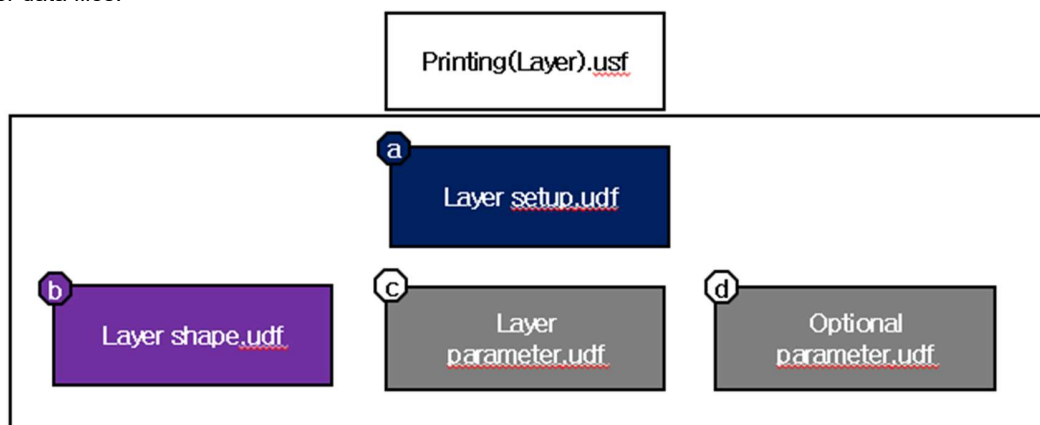
Users can adjust the parameters regarding the dispensing of various biomaterials and save them as a Dispensing parameters.udf file. More on this at Section III.-C1.-2.-[\[b. Dispensing Parameters\]](#).

c. Cross-linking Parameters

Users can adjust the parameters regarding the Cross-linking of materials and save them as a Cross-linking parameters.udf file. More on this at section III.-C1.-2.-[\[c. Cross-linking Parameters\]](#).

2. Layer-Based Printing Files

Users can print 3D biological tissue in layer-by-layer fashion without resorting to 3D CAD files (e.g. STL files). Each layer-specific printing parameters and shape, including crosslinking options, are composed of the following user data files.



a. Layer setup

Users define the printing and crosslinking sequence of each layer in 3D structure, and save the information in Layer procedure.udf file, which is based on the information defined by Layer shape, Layer parameter, and Optional parameter listed below.

More on this at section III.-C3.-2.-[\[a. Global Options\]](#), [\[b. Layers\]](#).

b. Layer shape

Users define the parameters regarding the shape and dispensing sequence of each layer, and save the information into Shape.udf file. More on this at section III.-C3.-2.-[\[c. Layer Shape\]](#).

c. Layer parameter

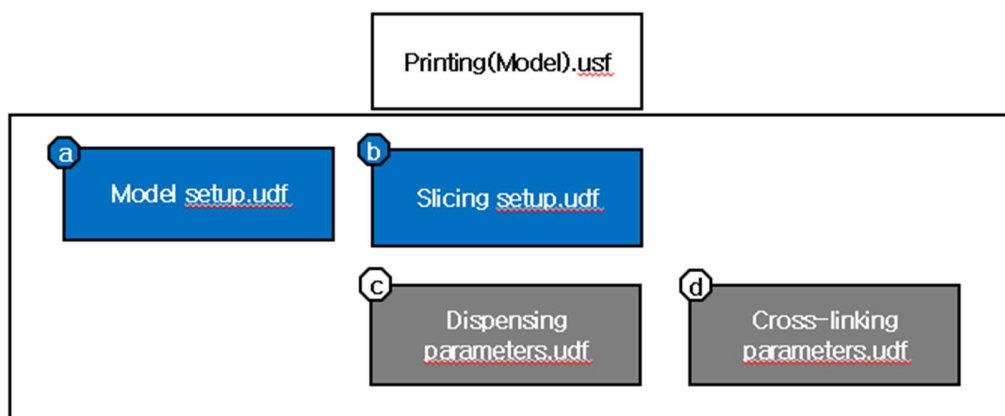
Users define the type of materials and their dispensing and crosslinking parameters, and save them into Printing parameter.udf file. More on this at section III.-C3.-2.-[\[d. Layer Parameters\]](#).

d. Optional parameter

Users define the layer-specific parameters about nozzle wiping and material flushing, and save them into Optional parameter.udf file. More on this at section III.-C3.-2.-[\[e. Wiping/Flushing\]](#).

3. Model-Based Printing Files

The Printing Files include the user data files listed below.



a. Model Setup

Users can adjust the parameters regarding the Coordinates, Scale, and Rotational values of the desired 3D model and save them as a Model setup.udf file. More on this at section III.-C4.-2.-[\[b. Model Setup\]](#).

b. Slicing Setup

Users can adjust the parameters regarding the layer thickness and planar resolutions of the desired 3D model and save them as a Slicing setup.udf file. More on this at section III.-C4.-2.-[\[c. Slicing Setup\]](#).

c. Dispensing Parameters

Users can adjust the parameters regarding the dispensing of each material and save them as a Slicing setup.udf file. More on this at section III.-C4.-3.-[\[b. Dispensing Parameters\]](#).

d. Cross-linking Parameters

Users can adjust the parameters regarding the Cross-linking of materials and save them as a Cross-linking parameters.udf file. More on this at section III.-C4.-3.-[\[c. Cross-linking Parameters\]](#).

II. Welcome Window

When the user starts the U-STUDIO program, a Welcome Window pops up over the Main Window. At the top of the Welcome Window, you will see the buttons that start A. Calibration (Single-Layer) / B. Calibration (Multi-Layer) / C. Layer-based Printing / D. Model-based Printing (in the center of the window), and E. Recents / F. Examples (at the bottom of the window). Users can begin a new workflow by pressing the A. Calibration (Single-Layer) / B. Calibration (Multi-Layer) / C. & D. Printing button or run a recently saved workflow by clicking on the files listed underneath D. Recents. Clicking on E. Examples lists the company-provided examples of U-STUDIO files that are available as samples to the user.



A. Single-Layer Calibration

Single-Layer Calibration allows the user to print a specific material in a single layer to find the desired parameters for 3D Printing, before the actual printing process.

The user can access the main window for Single-Layer Calibration by pressing the A. Calibration (Single-Layer) button. These parameters can be used during Multi-Layer Calibration to examine the fidelity of the printed structure. More on this at section III.-[\[C1. Workflow UI – Calibration\(Single-Layer\)\]](#).

B. Multi-Layer Calibration

Multi-Layer Calibration allows the user to print the materials in multiple layers to find the desired parameters for 3D Printing, before the actual printing process.

The user can access the main window for Multi-Layer Calibration by pressing the B. Calibration (Multi-Layer) button. The user can use the parameters set through Single-Layer Calibration to execute Multi-Layer Calibration and select the parameters best suited for optimal 3D bioprinting. It is also possible to use the parameters set through Multi-Layer Calibration to print actual 3D models.

More on this at section III.-[\[C2. Workflow UI – Calibration\(Multi-Layer\)\]](#).

C. Layer-Based Printing

By clicking the C. Printing(Layer-Based) icon, users can enter into the GUI that enables printing 3D biological tissue in layer-by-layer fashion without using 3D CAD files (e.g. STL files). Each layer-specific printing parameters and shape, including crosslinking options, are composed of the user data files described in I.-B.-[\[2.Layer-Based Printing Files\]](#). The user can use the parameters set through Single-Layer Calibration to execute Multi-Layer Calibration and select the parameters best suited for optimal 3D bioprinting. It is also possible to use the parameters set through Multi-Layer Calibration to print actual 3D models.

More on this at section III.-[\[C3. Workflow UI – Layer-Based Printing\]](#).

D. Model-Based Printing

After calibration procedures, the user prints an actual 3D model imported from external CAD files (such as STL files). The main window for Printing can be accessed by clicking on the D. Printing (Model-Based) icon. Each model-specific printing parameters and crosslinking options are composed of the user data files described in I.-B.-[\[3. Model-Based Printing Files\]](#). The user can use the parameters set through Single- or Multi-Layer Calibration to print a 3D model. Note: if the user is dissatisfied with the printed 3D model, it is possible to reprint after adjusting the parameters through re-calibrations.

More on this at section III.-[\[C4. Workflow UI – Model-Based Printing\]](#).

E. Recents

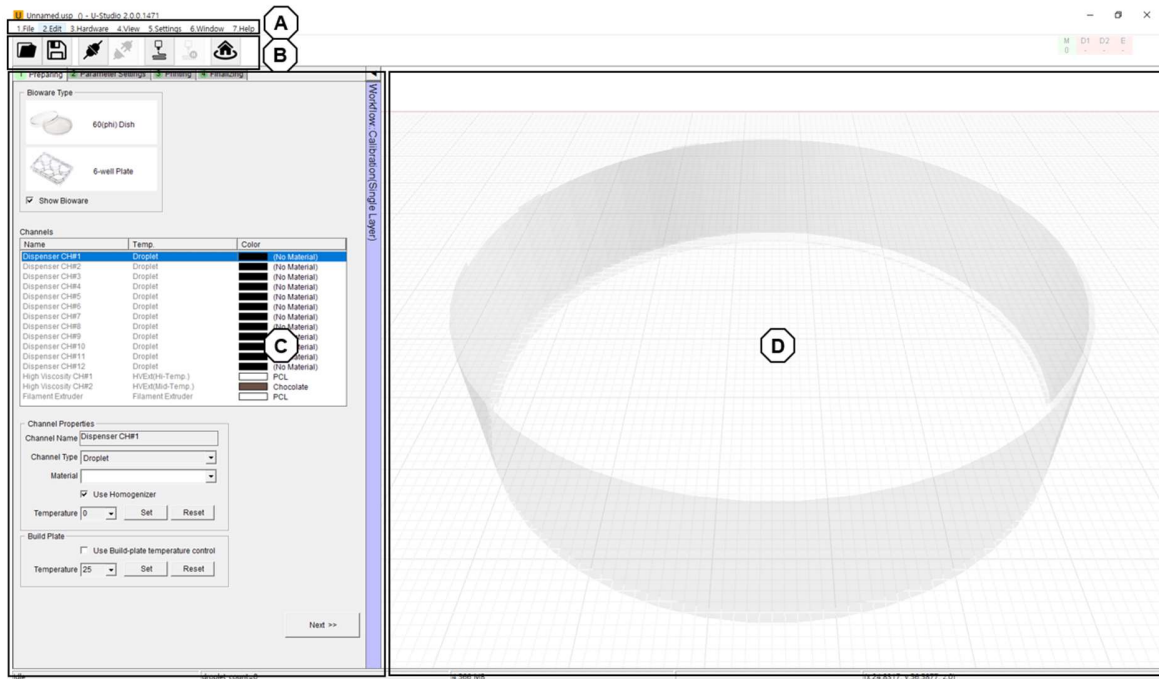
Displays saved files in order of saved dates. The user can select/execute the files.

F. Examples

Displays the example files offered by the U-STUDIO program. The user can select/execute the files.

III. Main Window

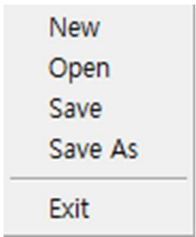
The user can run Calibration (Single-Layer) / Calibration (Multi-Layer) / Layer-Based Printing / Model-Based Printing / Recents / Examples from the Welcome Window. Please use the ESC key to enter the Main Window. The Main Window includes the **A. Menu Bar**, **B. Icon Bar**, **C. Workflow UI**, and **D. Model Viewer**



A. Menu Bar

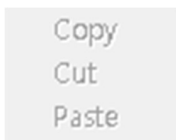
The Menu Bar has **1. File / 2. Edit / 3. Hardware / 4. View / 5. Settings / 6. Window / 7. Help** tabs.

1. File

	<p>The following options are displayed when pressing the File button from the Menu Bar.</p> <ol style="list-style-type: none"> New Open Save Save As Exit
---	---

- New**
When the user presses the New button, the Welcome Window restarts.
- Open**
When the user presses the Open button, the user can open a saved file.
- Save**
When the user presses the Save button, the user can save their project.
- Save As**
When the user presses the Save As button, the user can save their project underneath a new file name.
- Exit**
When the user presses the Exit button, the user can close the Main Window. They can also save their project before exiting.

2. Edit

	<p>The following options are displayed when pressing the Edit button from the Menu Bar.</p> <ol style="list-style-type: none"> Copy Cut Paste
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a. Copy

The user can copy the 3D model file(.stl) onto the printing platform.

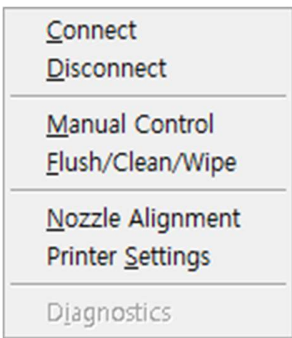
b. Cut

The user can cut the 3D model file(.stl) from the printing platform.

c. Paste

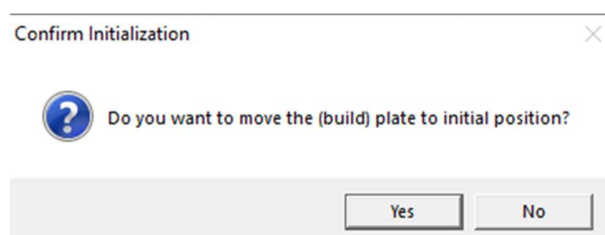
The user can paste a 3D model file(.stl) onto the printing platform (typically used in tandem with Cut/Copy).

3. Hardware

	<p>The following options are displayed when pressing the Hardware button from the Menu Bar.</p> <ol style="list-style-type: none"> Connect Disconnect Manual Control Flush/Clean/Wipe Nozzle Alignment Printer Settings
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a. Connect

When the user presses the Connect button, the user connects the U-FAB to the computer of U-FAB. Before the connection, a prompt asks if the user wants to initialize Homing function (Moving the build-plate to the initial position). If the user initializes Homing, the computer and U-FAB connect and the build-plate moves to the Initial reference position of the U-FAB.

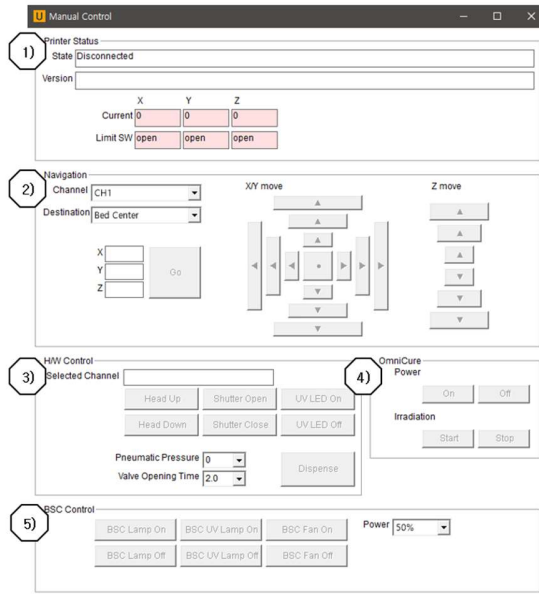


b. Disconnect

When the user presses the Disconnect button, the user disables the connection between the computer and the U-FAB. While the computer is disconnected, the user cannot control the U-FAB. However, they can still perform tasks that do not need the printing hardware, for example, making and editing new files within U-STUDIO.

c. Manual Control

When the user presses the Manual Control button, a window pops up. This allows for manual control of the hardware functions of the U-FAB (listed below).



The Manual Control window includes the following:

- 1) Printer Status
- 2) Navigation
- 3) H/W Control
- 4) Omnicure
- 5) BSC Control

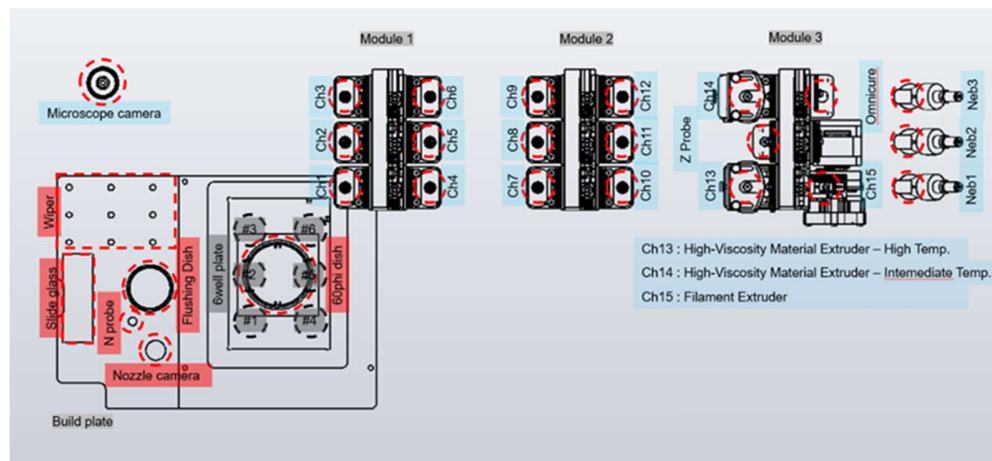
1) Printer Status

Displays the connection status of the computer to the U-FAB, the coordinate of the build-plate, and a firmware version.

- State: Displays the connection status of the U-FAB. (Connected / Disconnected)
- Version: Displays the firmware version of the U-FAB.
- Current: Displays the current coordinates of the U-FAB Build-plate.
- Limit Switch: Displays if the U-FAB's build-plate has reached the maximum allowed X/Y/Z coordinates. (Toggled / Open)
- Toggled: The build-plate has reached the maximum allowed X/Y/Z coordinates in the U-FAB.
- Open: The build-plate has not reached the maximum allowed X/Y/Z coordinates in the U-FAB.

2) Navigation

Function that allows the user to move the U-FAB's build-plate. The user can move the build-plate to a designated channel, or navigate the build-plate through the X,Y or Z Movement Icons, represented in small triangles corresponding to the directions.



[Location of Channels on the Build-plate]

- Channel: Allows the user to designate the U-FAB's channel. See the blue highlights of text/figures from the above [Build-plate and Channel Locations] to see the individual locations of each channel.
- Destination: Allows the user to designate the specific location of the Build-plate. See the yellow highlights of text/figures from the [Build-plate and Channel Locations].
- Go: When the user presses the Go button, the build-plate will move to the designated location.
- X/Y Move: The user can use the Movement Icons to move the build-plate along the X/Y axis directions in 1/10/100 mm increments.
- Z Move: The user can use the Movement Icon to move the build-plate along the Z axis directions in

1/10/100 mm increments.

3) Hardware Control

- Selected Channel: Displays the channel that the user designated in Navigation.
- Head Up/Down: Moves the designated channel in Z-axis directions by 30mm. This is to prevent interference from other channels during printing.
- Shutter Open/Close: Opens or closes the Shutter on the bottom of the user's designated Droplet-type channel.
- UV LED On/Off: Allows the user to turn on or off the UV LED of the designated channel.
- 'Pneumatic Pressure': Allows the user to set the Pneumatic Pressure within their designated channel.
- 'Valve Opening Time': Allows the user to set the amount of time that the designated channel's valve is open. While the valve is open, the contents of the channel are dispensed.
- 'Dispense': When the user presses the Dispense button, the designated channel begins dispensing.

[Note] All functions denoted by above ' ' are required when cleaning the nozzle or inspecting its condition.

4) Omnicure

- Power On/Off: Allows the user to turn the Omnicure's main power on or off.
- Irradiation Start/Stop: Allows the user to start or stop the UV irradiation from the Omnicure's Light Guide.

5) Biosafety Cabinet(BSC) Controls

- BSC Lamp On/Off: Allows the user to turn on or off the U-FAB's internal light.
- BSC UV Lamp On/Off: Allows the user to turn on or off the U-FAB's internal UV light (used for sterilization of inner surface of the cabinet).
- BSC Fan On/Off: Allows the user to turn on or off the U-FAB's internal air blower.
- Power: Allows the user to control the aerodynamic strength of the U-FAB's air blower.

d. Flush/Clean/Wipe

When the user presses the Flush/Clean/Wipe button, a window pops up. It allows the flushing/cleaning of the syringe in each printing channels and wiping the nozzle tip (in case there is droplet formation on the tip).

The screenshot shows the 'Flush/Clean/Wipe' window. It contains four main sections: 1) Channel List (a table with columns Name, Dispenser Type, and Color), 2) Designation (fields for Current Location X, Y, Z and a Position dropdown), 3) Flushing / Cleaning (Presets dropdown, Pressure and Valve Opening Time fields, and Start/Stop buttons), and 4) Droplet Nozzle Wiping (Wiper Position dropdown, Rotate position checkbox, Method dropdown, Count field, and Wipe button).

The Flush/Clean/Wipe window includes the following.

- 1) Channel List
- 2) Designation
- 3) Flushing/Cleaning
- 4) Droplet Nozzle Wiping

1) Channel List

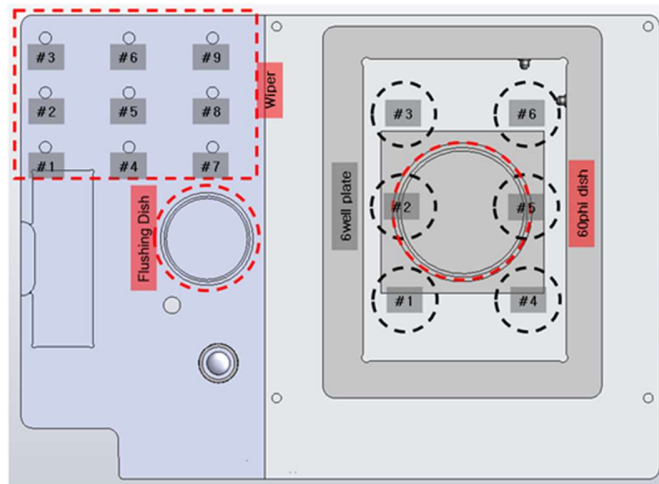
The Channel List displays the types of material in each channel, and the channel types connected to the U-FAB Driving Module. The user designates a channel for wiping the nozzle tip.

2) Designation

The user can choose the location of Flushing/Cleaning to take place for the designated channel.

This is a detailed view of the 'Designation' section. It includes input fields for 'Current Location X', 'Y', and 'Z', each with a value of '0'. Below these is a 'Position' dropdown menu currently set to 'Flushing dish(Trash)'. At the bottom is a 'Go' button.

- Current Location: Displays the current location of the designated channel.
- Position
 - Flushing dish(Trash)(35mm): The central coordinates of the build-plate's designated Flushing dish.
 - Build-plate Center: The central coordinates of the build-plate.
 - 6-well plate: The central coordinates of the 6-well plate's designated well(#1~6).
 - * More on this under next page's [Important spatial indices on the Build-plate].
- Go: When the user presses the Go button, the designated channel will move to the designated location.

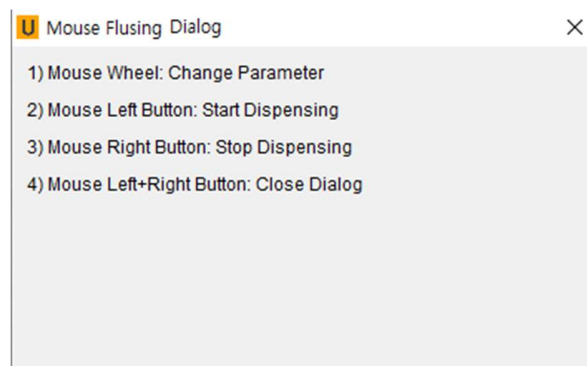


[Important coordinates on the Build-plate for the Wiper and the 6-well dish]

3) Flushing/Cleaning

Function that allows the user to choose the method of Flushing/Cleaning in the designated channel.

- Presets: The user can use the saved Flushing/Cleaning values or set and save new values through Custom.
- Save Presets: Saves the user set values for Pressure and Valve Opening Time as a Flushing/Cleaning Presets(.udf).
- Pressure: Sets the pneumatic pressure within the designated channel. (units: psi)
- Valve Opening Time: Sets the amount of time the designated channel's valve is open. While the valve is open, the channel will be flushed. (units: msec)
- Start: When the user presses the Start button, Flushing begins in the designated channel. When the user selects a channel from the channel list, the name of the button will change to match the channel's type.
- Stop: When the user presses the Stop button, flushing will stop in the designated channel.
- Mouse Click Flushing: This is a convenience feature designed to allow the user to flush the U-FAB's channels without looking at the monitor. When the user presses the Mouse click Flushing button, a screen pops up. Then, the user can execute the processes that are involved with flushing by pressing the corresponding mouse buttons.

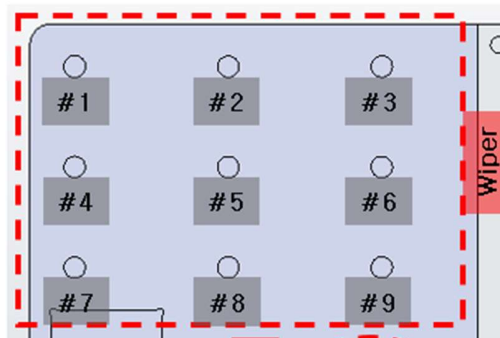


- 4) Droplet Nozzle Wiping
The user can choose the method of wiping for the Droplet-type channel.

Droplet Nozzle Wiping

Wiper Position
☒ Rotate position
 Method
 Count

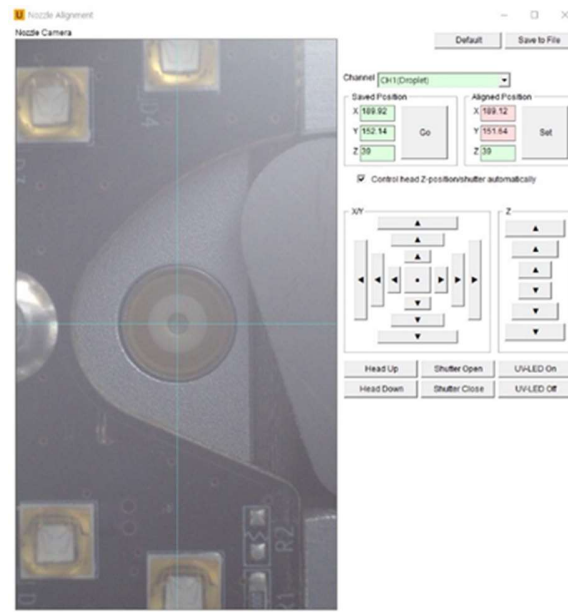
- Wiper Position: The user can choose the location of a specific wiper they wish to use(#1~9).



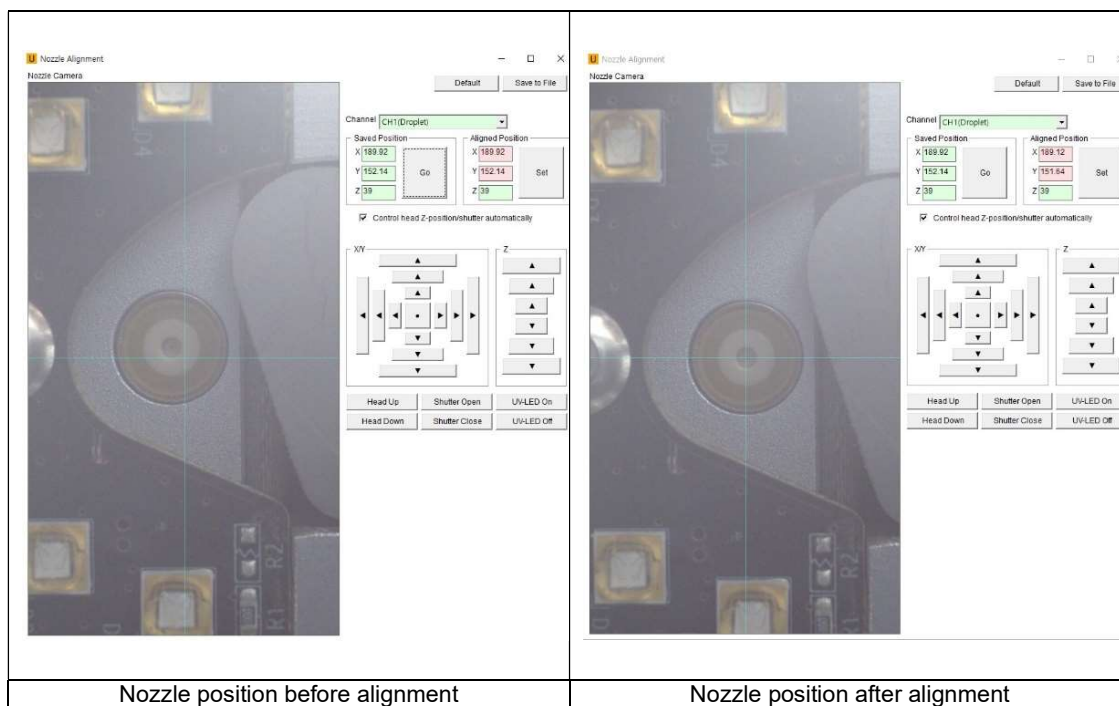
- Rotate position: When selected, the Droplet-type channel's nozzle is wiped first at the user's chosen wiper, and then is automatically wiped at the next wiper location.
- Method (Touch/Rub): The user can select the wiping method of the Droplet-type channel. The 'Touch' wipes by contacting the nozzle with the wiper once, while the 'Rub' wipes by the nozzle drying a circle on the wiper.
- Count: The user can choose how many times the nozzle gets wiped.
- Wipe: When the user presses the Wipe button, the nozzle is wiped.

e. Nozzle Alignment

When the user selects Nozzle Alignment, a window pops up. This allows the calibration of the designated channel's nozzle position through on-board camera looking at the nozzle from the bottom. The user can use nozzle alignment to correct for small spatial errors that may happen while operating the U-FAB.



- Nozzle Camera: The user can confirm each channel's nozzle position through the Nozzle alignment camera at the bottom left of the build-plate.
- Channel: The user can designate the channel they are trying to calibrate.
- Default: If the user presses the Default button, the default coordinate values offered by the U-FAB are loaded.
- Save Data: When the user presses the Save Data button, the aligned coordinates are saved.
- Saved Position: The saved nozzle position of each channel is displayed. When the user presses the Go button, the Nozzle alignment camera moves to the saved position.
- Aligned Position: The user can press the X/Y and Z movement icons (the buttons with a triangle inside) to display the aligned nozzle position. They can then press the Set button to temporarily save the aligned position.
- Control head Z-position / Shutter Automatically: When selected, the Z-axis moves Up/Down to calibrate the nozzle monitoring camera. The shutter on the bottom of the Droplet-type channel automatically opens as well.
- X/Y, Z: The user can press the X/Y and Z movement icons (the buttons with a triangle inside) to move the nozzle monitoring camera in 0.01/0.1/1 mm increments.
- Head Up/Down: Function that moves the designated channel in Z-axis directions by 30mm. This is to prevent interference from other channels during printing operation.
- Shutter Open/Close: The user can use the Shutter Open/Close function to check if the shutter on the bottom of the Droplet-type channel is functioning properly.
- UV-LED On/Off: The user can use the UV-LED On/Off function to check if the UV-LED on the bottom of the Droplet-type channel is functioning properly.

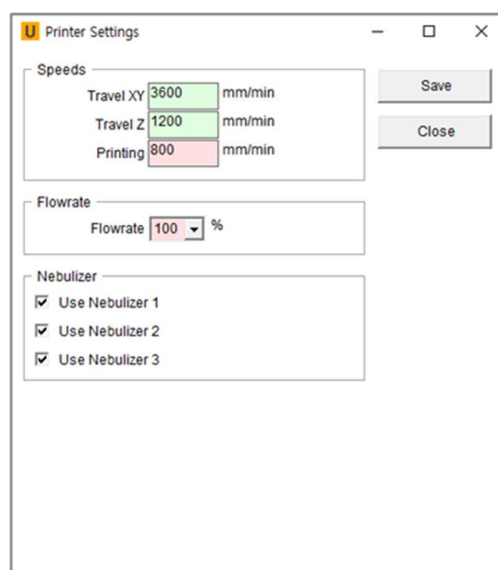


* The sequence of Nozzle Position Alignment

- 1) When the user selects a channel for nozzle position alignment, the Saved Position is displayed. The user then presses the Go button to move the nozzle camera to the Saved Position.
- 2) The user checks if the crosshair is centered on the nozzle, through the monitoring camera. If it is not centered, follow the instructions below.
- 3) The user first focuses the camera lens by using the Z-Axis Movement Icon (the buttons with a triangle inside), and then the X/Y Axis Movement Icons (the buttons with a triangle inside). The user then checks the calibrated position (displayed in the Aligned Position box) and temporarily saves the channel's position by pressing the Set button.
- 4) After the user finishes aligning each channel's nozzle position, pressing the Save Data button will save the aligned Nozzle positions for all of the channels.

f. Printer Settings


When the user presses the Printer Settings button, a window pops up. The window designates the U-FAB's build-plate's speed/filament extrusion amount/Whether to Use Nebulizer. If the user does not edit these values, the system uses the default values offered by U-STUDIO.

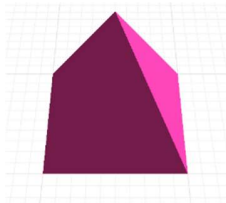
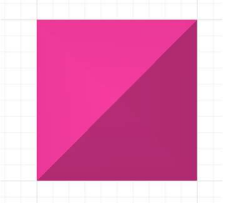
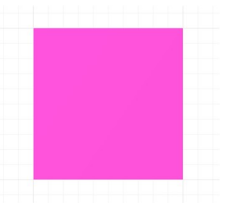
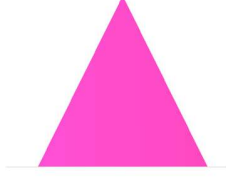
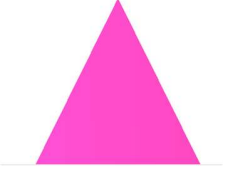


- Speeds: Displays the speed at which the build-plate is moving in X/Y/Z-axis directions. Users can adjust the speed. (measurement: mm/min)
 - Travel XY: Displays the speed of the build-plate's movement in X/Y-axis directions while it is not printing.
 - Travel Z: Displays the speed of the build-plate's movement in the Z-axis direction while it is not printing.
 - Printing: Displays the speed at which the build-plate is moving in X/Y/Z-axis directions during printing.
- Flowrate: The user can adjust the amount of material extruded from the filament extruder channel. (Base extrusion rate: 100%)
- Nebulizer: The user can select a checkbox to choose which Nebulizer to use. The location of the Nebulizers can be found under [Location of Channels on the Build Plate].

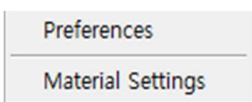
4. View

The user can see the 3D model in each direction, as shown in the picture, when they press the View button from the Menu Bar.

	<ul style="list-style-type: none"> - Perspective - Top - Bottom - Front - Back - Left - Right
---	--

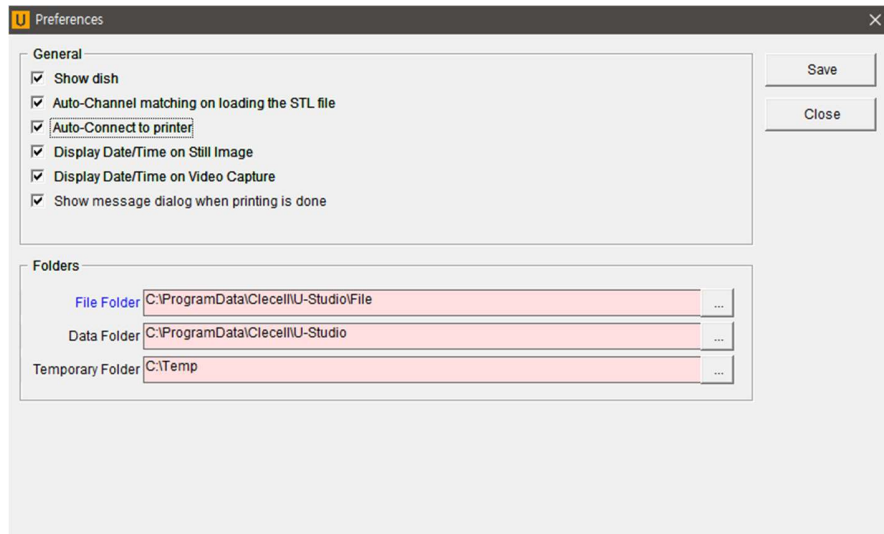
		
Perspective	Top	Bottom
		
Front/Back	Left/Right	

5. Settings

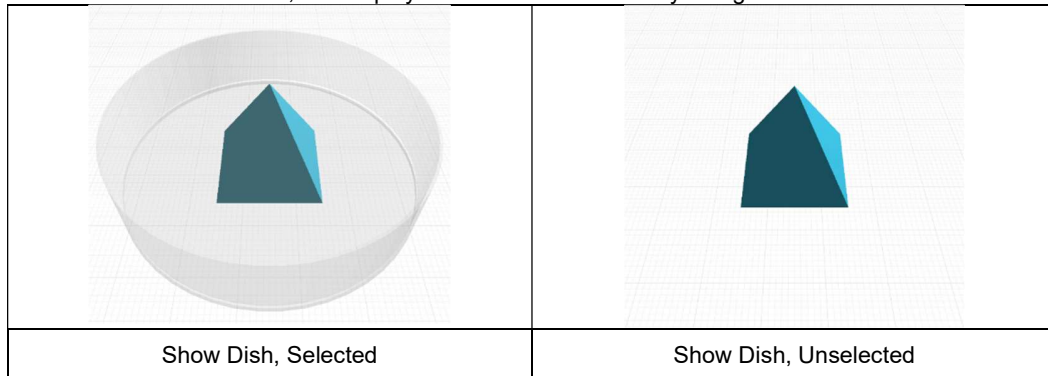
	<p>The following options are displayed when pressing the Settings button from the Menu Bar.</p> <p>a. Preferences</p> <p>b. Material Settings</p>
---	---

a. Preferences

When the user presses the Preferences button, a window pops up. This allows the selection of Additional functions for user convenience.



- Show Dish: When selected, this displays the dish that is currently being used in the Model Viewer.



- Auto-Channel matching on loading the STL File: When selected, the software scans for the material names under the selected 3D file. It then automatically chooses a channel for use. (Useful when the user imports a 3D Model that has multiple materials to the U-STUDIO.)
- Auto-Connect to printer: When selected, the computer and U-FAB will automatically connect when starting the U-STUDIO program.
- Display Date/Time on Still Image: When selected, the saved image from the monitoring camera will contain the date/time of acquisition.
- Display Date/Time on Video Capture: When selected, the saved video from the monitoring camera will contain the date/time of acquisition.
- Show message dialog when printing is done: When selected, after printing concludes, the Start time, Finish time, and Elapsed time of the printing process will be displayed through the pop-up.
- Folders: If the user clicks '...', it allows selection of a specific folder to save files for U-STUDIO.

b. Material Settings

When the user presses the Material Settings button, a menu that allows the user to input information of each material will be displayed. If the user does not input information about each material, the default values offered by U-STUDIO will be displayed.

Name	Best temp.	Viscosity	Color
Collagen	37.0	200.0	
FB-medium	37.0	300.0	
Gelatine	40.0	0.0	
GelMA	25.0	500.0	
KC-medium	37.0	0.0	
MC-medium	37.0	0.0	
MEL	25.0	500.0	
NaHCO3	37.0	0.0	
PCL	80.0	0.0	
Pluronic F-127	10.0	3000.0	

General info.

Name:

Description:

Best Temp: °C

Viscosity: cp

Color:

- Name: The user can input the name of the material.
- Description: The user can input detailed information about the material.
- Best Temperature: The user can input the optimal printing temperature of the material.
- Viscosity: The user can input the information pertaining to the viscosity of the material.
- Color: The user can choose the color that will be used to display the material in the Model Viewer.

6. Window

<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;">Workflow UI</div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;">Cross-Section</div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;">Monitoring Camera</div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;">Microscope Camera</div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;">Channel Status</div> <div style="border: 1px solid #ccc; padding: 5px;">Skin Model Generator</div>	<p>The following options are displayed when pressing the Window button from the Menu Bar</p> <p>a. Workflow UI</p> <p>b. Cross-Section</p> <p>c. Monitoring Camera</p> <p>d. Microscope Camera</p> <p>e. Channel Status</p>
---	--

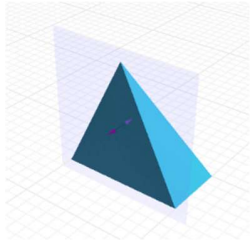
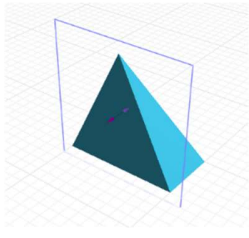
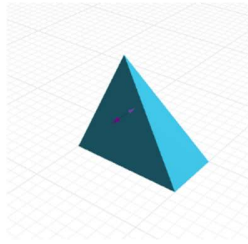
a. Workflow UI

When the user presses the Workflow UI button, the Workflow UI will be enabled or disabled in the main window. More on this at section III.-[\[C1.-C4. Workflow UI\]](#).


b. Cross-Section

When the user presses the Cross-Section button, a menu that will allow the user to check the model's cross section will be displayed in the Model Viewer.

<p>Cross-Section</p> <p>Plane Setup</p> <p>Plane direction: <input type="text" value="XZ-plane"/></p> <p>Offset Y: <input type="text" value="0"/></p> <p>Plane type: <input type="text" value="Translucent"/></p> <p><input type="button" value="Close"/></p>	<p>Select XZ-plane</p>	<p>Select YZ-plane</p>
Cross-Section Window		

		
Plane type : Translucent	Plane type : Border-only	Plane type : Hidden
<ul style="list-style-type: none"> - Plane direction: Sets the direction of the cross section in the 3D model (XZ-plane / YZ-plane) - Offset(X/Y): With the origin point as the anchor, the user can move the location of the cross-sectional plane in X or Y-axis directions. - Plane type: Chooses the display method of the 3D model's cross section. (Translucent / Border-only / Hidden) 		

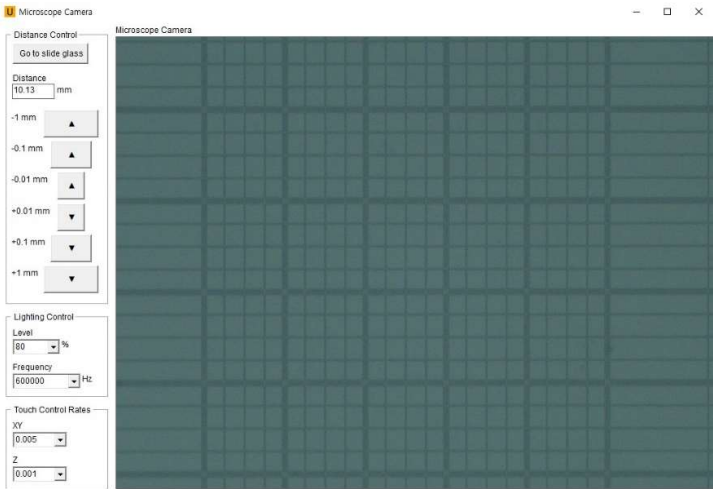
c. Monitoring Camera



The image shows a window titled "Monitoring Camera" with a yellow icon. Inside the window is a video feed of a 3D printed part, which appears to be a clear, multi-walled structure with several circular openings, possibly a filter or a container component. The background of the window is dark.

When the user presses the Monitoring Camera button, you can observe the materials being printed through the monitoring camera. The user can then save the video, parts of the video, or both as still images.

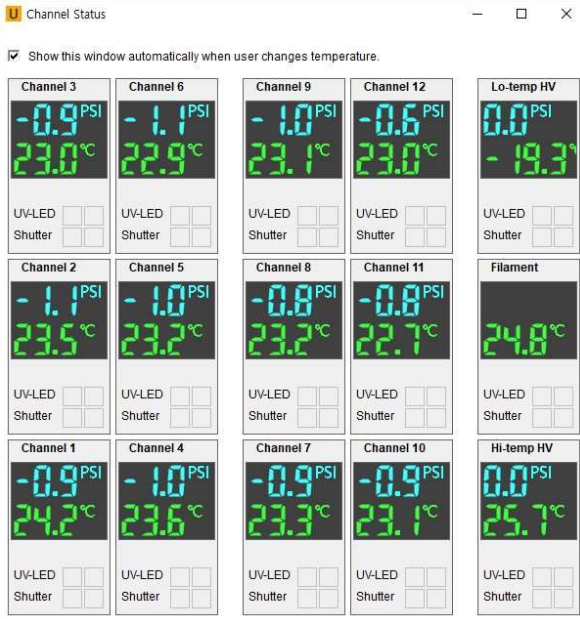
d. Microscope Camera



When the user presses the Microscope Camera button, they can then observe the Slide glass (Hematocytometer) through the Microscope.

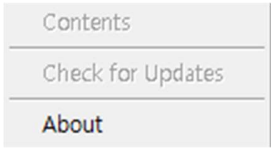
- Go to Slide glass: When the user presses the Go to Slide glass button, the build-plate moves until the user can observe the Slide glass through the microscope.
- Distance: Displays the microscope's focus point. The user can use the movement icons (the buttons with a triangle inside) to focus the camera lens.

e. Channel Status



When the user clicks on Channel Status, the Pneumatic pressure / Temperature / UV-LED Status / Shutter Status of all U-FAB channels are displayed. If the user changes the channel temperature through channel settings, the Channel Status window will automatically pop up.

7. Help

	<p>The following options are displayed when pressing the Help button from the Menu Bar.</p> <ul style="list-style-type: none">a. Contentsb. Check for Updatesc. About
---	--

a. Contents

When selected, short lists of U-STUDIO functions U-STUDIOare displayed.

b. Check for Updates

When selected, information regarding any updates on firmware versions of the U-FAB and U-STUDIO software will be displayed.

c. About

When selected, the U-STUDIO's software version and Copyright information are displayed.










B. Icon Bar

The following icons are displayed on the Icon Bar.



M	D1	D2	E
-	-	-	-

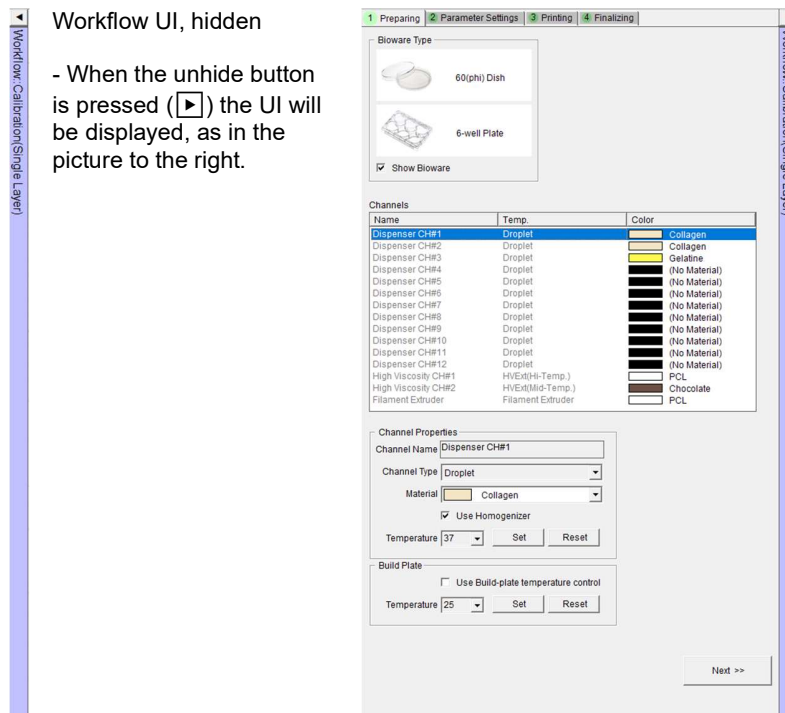
	When selected, the user can load U-STUDIO files. (Same function as (File>Open) from Menu Bar)								
	When selected, the user can save U-STUDIO files. (Same function as (File>Save) from Menu Bar)								
	When selected, the U-FAB and the computer connects. (Is ungrayed when the U-FAB is not connected.)								
	When selected, the U-FAB and the computer disconnects. (Is ungrayed when the U-FAB is connected.)								
	When selected, prints in the parameters inputted by the user. (Is ungrayed when it is possible to print.)								
	When selected, the user can temporarily stop all operations occurring within the U-FAB. Afterwards, the user can either resume or terminate operations.								
	When selected, the printer submodules move to their initial reference positions.								
<table border="1"><tr><td>M</td><td>D1</td><td>D2</td><td>E</td></tr><tr><td>0</td><td>-</td><td>-</td><td>-</td></tr></table>	M	D1	D2	E	0	-	-	-	Displays the connection between the U-FAB and the computer in real-time. (Green Icon:Connected/Red Icon:Disconnected)
M	D1	D2	E						
0	-	-	-						

C1. Workflow UI – Single-Layer Calibration

Workflow UI is a menu that is displayed at the bottom of the Main Window's left Icon Bar. When the user presses the Single-Layer Calibration button from the Welcome Window, the Workflow UI for Single-Layer Calibration will be displayed on the Main Window.

The Workflow UI for Single-Layer Calibration consists of the tabs for 1. Preparing, 2. Parameter Setting, 3. Printing, and 4. Finalizing.

The user can use the hide button (◀) or the unhide button (▶) to hide or unhide the Workflow UI.



- If the user hides the Workflow UI, they can enlarge the III.-[D.Model Viewer] window.

1. Preparing Tab

Bioware Type

60(phi) Dish

6-well Plate

☒ Show Bioware

Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	Collagen
Dispenser CH#3	Droplet	Gelatin
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Chocolate
Filament Extruder	Filament Extruder	PCL

Channel Properties

Channel Name: Dispenser CH#1

Channel Type: Droplet

Material: Collagen

☒ Use Homogenizer

Temperature: 37 Set Reset

Build Plate

☐ Use Build-plate temperature control

Temperature: 25 Set Reset

Next >>

The following options are displayed when pressing the 1. Preparing button.

- a. Bioware Type
- b. Channels
- c. Channel Properties
- d. Build-plate

When everything is set, the user can press the Next button to enter 2. Parameter Settings.

a. Bioware Type

Bioware Type

60(phi) Dish

6-well Plate

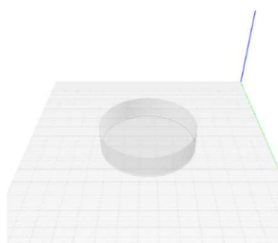
☒ Show Bioware

Target Well

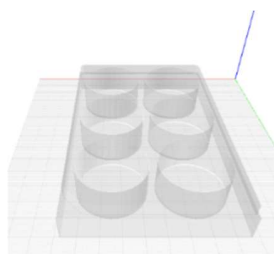
Printing Target: 1

The user can select the 60(phi) Dish (60mm inner diameter) or 6-well Plate (each 35mm inner diameter) to designate which bioware to run Calibration process.

- Show Bioware: When selected, this displays the designated Bioware in the Model Viewer.
- Target Well: The user can designate the location of the well (#1~6) from the 6-well Plate where the printing occurs.


















60(phi) Dish



6-well Plate

b. Channels

Displays name and type of Channels used in the U-FAB. The user can select each channel to change Channel Properties.

Channels		
Name	Type	Color(Material)
Dispenser CH#1	Droplet	 Collagen
Dispenser CH#2	Droplet	 Collagen
Dispenser CH#3	Droplet	 Gelatine
Dispenser CH#4	Droplet	 (No Material)
Dispenser CH#5	Droplet	 (No Material)
Dispenser CH#6	Droplet	 (No Material)
Dispenser CH#7	Droplet	 (No Material)
Dispenser CH#8	Droplet	 (No Material)
Dispenser CH#9	Droplet	 (No Material)
Dispenser CH#10	Droplet	 (No Material)
Dispenser CH#11	Droplet	 (No Material)
Dispenser CH#12	Droplet	 (No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	 (No Material)
High Viscosity CH#2	HVExt(Mid-Temp.)	 (No Material)
Filament Extruder	Filament Extruder	 (No Material)

- Displayed information: Channel name / Channel type / Materials used / Material color within the Model Viewer
- Because the U-STUDIO cannot detect the materials used within each channel of the U-FAB, the user must check if the materials loaded into each U-FAB channel matches with the material displayed in the U-STUDIO channel.


c. Channel Properties

Function that sets the Properties of the designated channel.

Channel Properties

Channel Name
Dispenser CH#1

Channel Type
Droplet

Material
 Collagen

☒ Use Homogenizer

Temperature
37
Set Temperature

- Channel Name: Displays the name of the designated channel.
- Channel Type: Sets the channel type of the designated channel.
- Material: Sets and displays the type of material the user set within III.-A.-5.-[\[b.Material Settings\]](#) in the designated channel.
- Use Homogenizer: When selected, automatically performs pipetting of the material within the channel to help prevent material or cells from clumping.
- Temperature: Allows the user to set the temperature of the designated channel.
- Set Temperature: When selected, changes and maintains the channel temperature.

[Channel Type Dropdown]

None

None

Droplet


Extrusion


Hi-Viscosity Extrusion(Hi-Temp.)


Hi-Viscosity Extrusion(Mid-Temp.)


Filament Extruder


[Material Dropdown]


 Chocolate


 Collagen


 FB-medium


 Fibrinogen


 Gelatine


 GelMA


 KC-medium


 MC-medium

 MEL

 NaHCO3

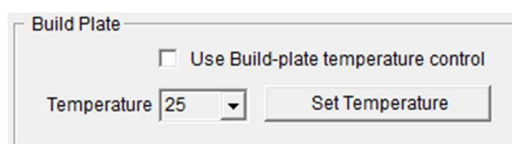
 PCL

 Pluronic F-127

 Thrombin

d. Build-plate

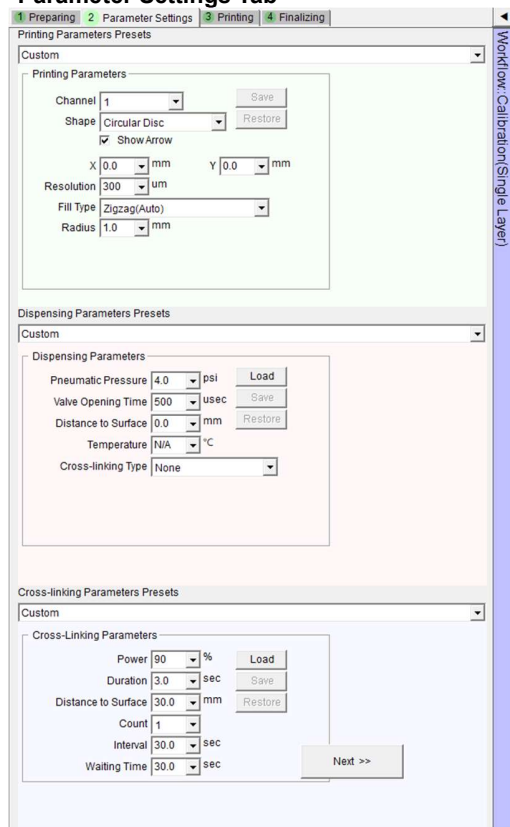
Function that allows the user to set the build-plate's temperature.



The Build Plate control panel features a checkbox labeled "Use Build-plate temperature control". Below it, there is a "Temperature" field with a dropdown menu currently showing "25", and a "Set Temperature" button.

- Use Build-plate temperature control: When selected, the user can access the build-plate temperature control function.
- Temperature: Allows the user to set the temperature of the build-plate.
- Set Temperature: When selected, changes the channel temperature to the desired temperature setting.

2. Parameter Settings Tab



The Parameter Settings Tab is divided into three main sections: Printing Parameters, Dispensing Parameters, and Cross-linking Parameters. Each section has a "Custom" preset selected. The Printing Parameters section includes fields for Channel (1), Shape (Circular Disc), Show Arrow (checked), X (0.0 mm), Y (0.0 mm), Resolution (300 um), Fill Type (Zigzag(Auto)), and Radius (1.0 mm). The Dispensing Parameters section includes fields for Pneumatic Pressure (4.0 psi), Valve Opening Time (500 usec), Distance to Surface (0.0 mm), Temperature (N/A °C), and Cross-linking Type (None). The Cross-linking Parameters section includes fields for Power (90 %), Duration (3.0 sec), Distance to Surface (30.0 mm), Count (1), Interval (30.0 sec), and Waiting Time (30.0 sec). A "Next >>" button is located at the bottom right of the Cross-linking Parameters section.

The following options are displayed when pressing the 2. Parameter Settings button.

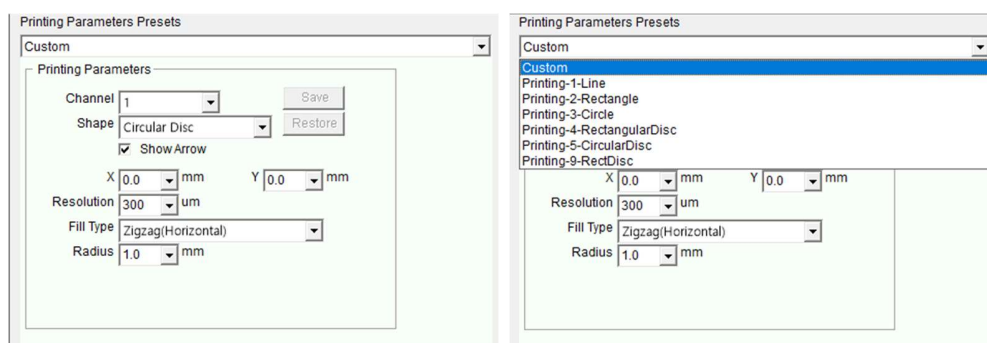
- a. Printing Parameters
- b. Dispensing Parameters
- c. Cross-linking Parameters

When everything is set, the user can press the Next button to enter 3. Printing

- Load: Load a set of previously saved printing parameters.
- Save: Save the parameters as a Preset (user-defined parameters saved as User Data Files)
- Restore: Load the default parameter values.

a. Printing Parameters

Allows the user to set the Printed shape and Fill Type. The Printing Parameters set by the user are displayed in real-time through the Model Viewer. After the setting is complete, the user can save the parameters as a Preset (user-defined parameters saved as User Data Files). If the Custom button is clicked, the Presets are displayed.



The Printing Parameters Presets dialog shows a list of presets: Custom, Printing-1-Line, Printing-2-Rectangle, Printing-3-Circle, Printing-4-RectangularDisc, Printing-5-CircularDisc, and Printing-9-RectDisc. The "Custom" preset is selected. Below the list, the parameters for the selected preset are displayed: X (0.0 mm), Y (0.0 mm), Resolution (300 um), Fill Type (Zigzag(Horizontal)), and Radius (1.0 mm).

1) Shape - Line

The screenshot shows a 'Custom' dialog box with a 'Printing Parameters' section. The 'Channel' is set to '1', 'Shape' is 'Line', and 'Show Arrow' is checked. The 'X' coordinate is '0.0 mm', 'Y' is '0.0 mm', 'Resolution' is '400 um', 'Count' is '2', 'Distance' is '1.0 mm', and 'Length' is '3.0 mm'. There are 'Save' and 'Restore' buttons. An inset image shows a grid of droplets forming a line.

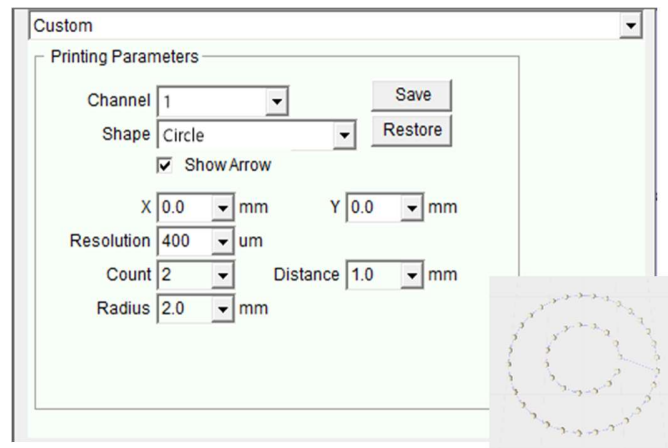
- Channel: The user can select a channel
- Shape[Line]: When selected, the material is printed as a line (see inset of above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets. (Printing spatial resolutions)
- Count: The user can choose the number of lines that will be printed.
- Distance: The user can choose the gap between the printed lines.
- Length: The user can choose the length of the printed line.

2) Shape – Rectangle

The screenshot shows a 'Custom' dialog box with a 'Printing Parameters' section. The 'Channel' is set to '1', 'Shape' is 'Rectangle', and 'Show Arrow' is checked. The 'X' coordinate is '0.0 mm', 'Y' is '0.0 mm', 'Resolution' is '400 um', 'Count' is '2', 'Distance' is '1.0 mm', 'Width' is '3.0 mm', and 'Height' is '3.0 mm'. There are 'Save' and 'Restore' buttons. An inset image shows a grid of droplets forming a rectangle.

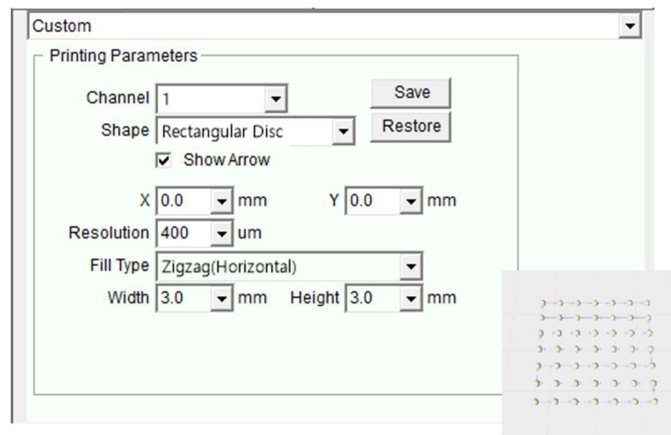
- Channel: The user can select a channel.
- Shape[Rectangle]: When selected, the material is printed as a rectangle (see inset of above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Count: The user can choose the number of rectangles that will be printed.
- Distance: The user can choose the gap between the printed rectangles.
- Width: The user can choose the printed rectangle's outer width.
- Height: The user can choose the printed rectangle's outer height.

3) Shape – Circle



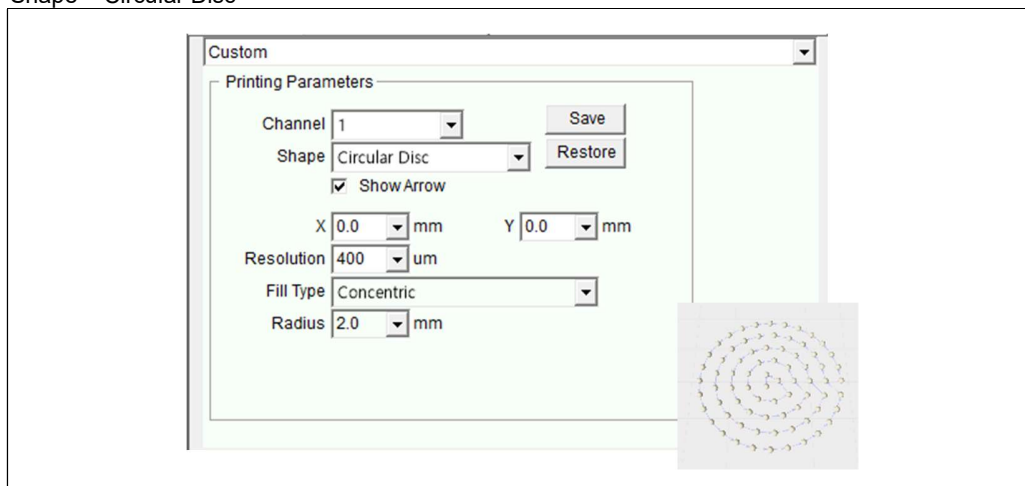
- Channel: The user can select a channel.
- Shape[Circle]: When selected, the material is printed as a circle (see inset of above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Count: The user can choose the number of circles that will be printed.
- Distance: The user can choose the gap between the printed circles.
- Radius: The user can choose the radius of the outer circle.

4) Shape - Rectangular Disc



- Channel: The user can select a channel.
- Shape[Rectangular Disc]: When selected, the material is printed as a filled rectangle (see inset of above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Fill Type: The user can choose how they will fill in the rectangle. (See the information below regarding 'Fill Type')
- Width: The user can choose the rectangle's width.
- Height: The user can choose the rectangle's height.

5) Shape – Circular Disc



- Channel: The user can select a channel.
- Shape[Circular Disc]: When selected, the material is printed as a filled circle (see inset of above figure).
- Show Arrow: When selected, the Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the center coordinate of the circles.
- Resolution: The user can choose the distance between the printed Droplets.
- Fill Type: The user can choose how they will fill in the circle. (See the information below regarding 'Fill Type')
- Radius: The user can define the outer-most radius.

- Fill Type: Ungrayed when selecting Rectangular Disc/Circle Disc. Allows the user to choose how they will fill in the rectangle or circle

Zigzag(Horizontal) : Fills in by going top to bottom, in a zigzag pattern.	Zigzag(Vertical) : Fills in by going left to right, in a zigzag pattern.	Concentric : Fills in by going from the outer diameter to the center
Gradient Rate : 0% : Fills in with a spatial gradient by going from the outer diameter to the center	Gradient Rate : 50% : Fills in with a spatial gradient by going from the outer diameter to the center	Gradient Rate : 100% : Fills in with a spatial gradient by going from the outer diameter to the center

b. Dispensing Parameters

Allows the user to set the parameters regarding dispensing.

- Pneumatic Pressure: Allows the user to set the applied pneumatic pressure to the channel.
- Valve Opening Time: Function that allows the user to set the amount of time the valve is open. While the valve is open, the material is printed.
- Distance to Surface: The user can set the height at which printing begins.
- Temperature: The user can set each channel's temperature. If the user has already set the temperature in the 'preparing' tab, they can select N/A. If the temperature setting needs revision, the user selects a new temperature.
- Cross-linking Type: The user can select the appropriate Cross-linking method.
 - 1) UV-LED (per Droplet)
 - : When one droplet is dispensed, UV-LEDs (located below the channel) irradiate the droplet. The user can change the duration of UV-LED irradiation from 'UV Irradiation Time'.
 - 2) UV-LED(per Layer)
 - : When a single layer is fully printed, the UV-LED then irradiates the entire layer. The user can change the duration of UV-LED irradiation from 'UV Irradiation Time'.
 - 3) Nebulizer
 - : The Nebulizer settings menu will be displayed (See c. Cross-linking Parameter)
 - 4) UV-Lamp
 - : The user can change how long the UV-Lamp (Omnicure) is turned on.

c. Cross-linking Parameters

Displayed when the user selects the Nebulizer as the Cross-linking Type from the Dispensing Parameters. It sets the operating parameters of the Nebulizer.

- Power: The user can choose the amount of nebulizing power as a percentage.
- Duration: The user can choose the duration of nebulization.
- Distance to Surface: The user can choose the height from the bioware at where the Nebulizer works.
- Count: The user can choose how many times the Nebulizer dispenses the crosslinking material.
- Interval: The user can choose the interval at which the Nebulizer dispenses, if the Nebulizer is continuously dispensing.
- Waiting Time: The user can choose the waiting period after nebulization and before printing so that proper crosslinking will be ensured. (i.e. crosslinking time may vary depending on the type and concentration of specific material),

3. Printing Tab

When the user presses the 3. Printing button, a menu that allows the user to execute Single-Layer Calibration.

- a. Monitoring Camera
- b. Progress
- c. Additional Printing Options
- d. Report

When everything is set, the user can press the Next button to enter 4. Finalizing.

a. Monitoring Camera

The Monitoring Camera takes video/pictures of the printing process in real-time. The user can archive the printing process as a video or image file.

- Automatic video recording while printing: When selected, the Monitoring Camera automatically films the printing process when it starts (saves as .mp4).
- Start Recording: When selected, manually begins filming the printing process (saves as .mp4).
- Save Image: When selected, a screenshot is saved (saved as .png).
- Video File: When the user presses the '...' button, they can choose the directory to save the video/image files.

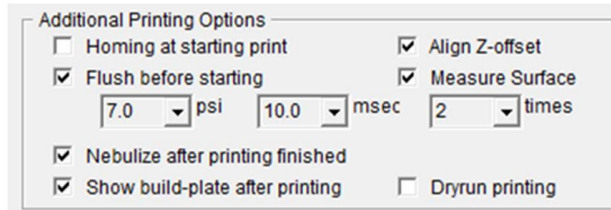
b. Printing Status

Displays information about the printing process in real-time.

- File: Displays the location of the file that is being printed.
- Progress: Displays the completion of the printing process as a Bar graph.
- Layer: Displays the current number of material layers.
- Current Job: If the printing process has not finished, Current Job displays as 'Printing'. If it is finished, it displays as 'Finished'.
- Start Time: Displays the time when the printing process began.
- Finish Time: Displays the time when the printing process will finish.
- Elapsed Time: Displays the amount of time left before the printing process concludes.
- Print / Pause: When the user presses the Print button, the printing process begins, and the Print button changes to the Pause button. When the user presses the Pause button, the printing process can be temporarily stopped.
- Resume: Appears when the Pause button is pressed. When clicked, it resumes the printing process.
- Cancel: Appears when the Pause button is pressed. When clicked, it terminates the printing process.

c. Additional Printing Options

Allows the user to select additional features for printing.



Additional Printing Options

☐ Homing at starting print ☒ Align Z-offset

☒ Flush before starting ☒ Measure Surface

7.0 psi 10.0 msec 2 times

☒ Nebulize after printing finished

☒ Show build-plate after printing ☐ Dryrun printing

- Homing at starting print: When selected, the build-plate moves to the Initial reference position of the U-FAB before the printing process begins.
- Align Z-offset: When selected, the build plate undergoes processes that adjust the vertical offset from the nozzle.
- Measure Surface: When selected, the distance between the buildplate and the nozzle is measured.
- Flush before starting: When selected, the channels are flushed before the printing process begins.
- Nebulize after printing finished:
- Show buile-plate after printing: When selected, the build-plate moves to the front panel of the U-FAB after the printing process finishes. When unselected, the build-plate stops at the location where the printing process finished.
- Dryrun printing: When selected, the users can simulate the entire printing process without dispensing any materials.

4. Finalizing Tab

The screenshot shows a software interface with a top navigation bar containing four tabs: '1 Preparing', '2 Parameter Settings', '3 Printing', and '4 Finalizing'. The '4 Finalizing' tab is active. The main area is divided into three sections, each with a 'Save Parameters' button at the bottom. The first section, 'Printing/Slicing Parameters', lists: Material Channel: 0, X: 0, Y: 0, Spatial resolution: 300 um, Shape: Circular Disc, and Radius: 1 mm. The second section, 'Dispensing Parameters', lists: Pneumatic pressure: 4 psi, Valve opening time: 500 usec, Distance to surface: 0 mm, and Temperature: N/A. The third section, 'Cross-Linking Parameters', lists: Nebulizing Power: 90 %, Duration: 3 sec, Distance to surface: 30 mm, Nebulizing Count: 1, Interval: 30 sec, and Waiting time: 30 sec. A vertical sidebar on the right is labeled 'Workflow: Calibration (Single Layer)'.

When the user presses the 4. Finalizing button, the parameters set during Single-Layer Calibration are displayed. The user can verify and save these parameters from the Finalizing Tab

a. Printing/Slicing Parameters

b. Dispensing Parameters

c. Cross-Linking Parameters

- Save Parameters: If the user presses the Save Parameters button, the parameters displayed under the Finalizing Tab are saved. If the user changes the parameters after viewing the finished printed model, this function becomes necessary to save the changed parameters.

a. Printing/Slicing Parameters

The user can verify and save the Printing/Slicing Parameters.

b. Dispensing Parameters

The user can verify and save the Dispensing Parameters.



c. Cross-Linking Parameters

The user can verify and save the Cross-Linking Parameters.

C2. Workflow UI – Multi-Layer Calibration


Workflow UI is a menu that is displayed at the bottom of the Main Window's left Icon Bar. When the user presses the Multi-Layer Calibration button from the Welcome Window, the Workflow UI for Multi-Layer Calibration will be displayed on the Main Window.

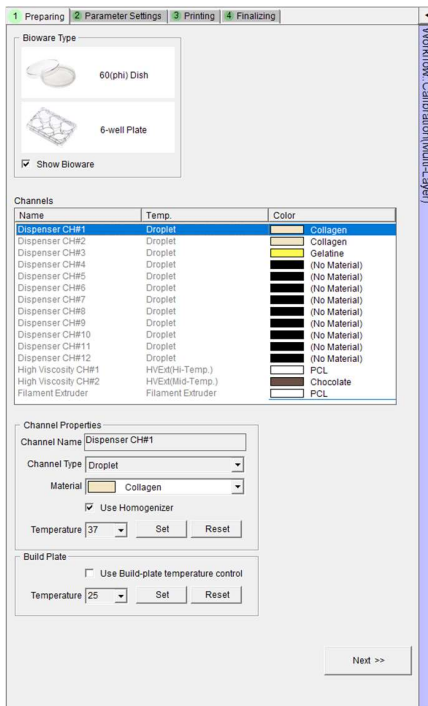
The Workflow UI for Multi-Layer Calibration, which is similar to the process for the Single-Layer Calibration, consists of the tabs for 1. Preparing, 2. Parameter Setting, 3. Printing, and 4. Finalizing.

The user can use the hide button() or the unhide button() to hide or unhide the Workflow UI.

Workflow Calibration (Multi-Layer)

Workflow UI, hidden

- When the unhide button is pressed () the UI will be displayed, like the picture to the right.



Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	Collagen
Dispenser CH#3	Droplet	Gelatin
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVE(Hi-Temp.)	PCL
High Viscosity CH#2	HVE(Mid-Temp.)	Chocolate
Filament Extruder	Filament Extruder	PCL

Channel Properties

Channel Name: Dispenser CH#1

Channel Type: Droplet

Material: Collagen

☒ Use Homogenizer

Temperature: 37 Set Reset


Build Plate

☐ Use Build-plate temperature control

Temperature: 25 Set Reset

Next >>

Workflow UI, in display

- When the hide button is pressed () the UI will be hidden, like the picture to the left.

- If the user hides the Workflow UI, they can enlarge the III. -[\[D.Model Viewer\]](#) window.

1. Preparing Tab

Bioware Type

60(phi) Dish

6-well Plate

☒ Show Bioware

Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	Collagen
Dispenser CH#3	Droplet	Gelatine
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Chocolate
Filament Extruder	Filament Extruder	PCL

Channel Properties

Channel Name: Dispenser CH#1

Channel Type: Droplet

Material: Collagen

☒ Use Homogenizer

Temperature: 37 Set Reset

Build Plate

☐ Use Build-plate temperature control

Temperature: 25 Set Reset

Next >>

The following options are displayed when pressing the 1. Preparing button.

- a. Bioware Type
- b. Channels
- c. Channel Properties
- d. Build-plate

When everything is set, the user can press the Next button to enter 2. Parameter Settings.

a. Bioware Type

Bioware Type

60(phi) Dish

6-well Plate

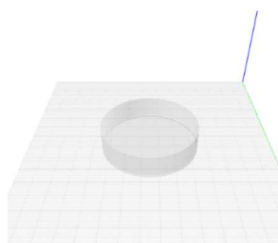
☒ Show Bioware

Target Well

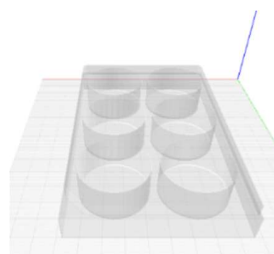
Printing Target: 1

The user can select the 60(phi) Dish (60mm inner diameter) or 6-well Plate (each 35mm inner diameter) to designate which bioware to run Calibration process.

- Show Bioware: When selected, this displays the designated Bioware in the Model Viewer.
- Target Well: The user can designate the location of the well (#1~6) from the 6-well Plate where the printing occurs.



60(phi) Dish



6-well Plate

b. Channels

Displays name and type of Channels used in the U-FAB. The user can select each channel to change Channel Properties.

Channels		
Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	Collagen
Dispenser CH#3	Droplet	Gelatine
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Chocolate
Filament Extruder	Filament Extruder	PCL

- Displayed information: Channel name / Channel type / Materials used / Material color within the Model Viewer
- Because the U-STUDIO cannot detect the materials used within each channel of the U-FAB, the user must check if the materials loaded into each U-FAB channel matches with the material displayed in the U-STUDIO channel.

c. Channel Properties

Function that sets the Properties of the designated channel.

Channel Properties

Channel Name
Dispenser CH#1

Channel Type
Droplet

Material
Collagen

☒ Use Homogenizer

Temperature
37
Set Temperature

- Channel Name: Displays the name of the designated channel.
- Channel Type: Sets the channel type of the designated channel.
- Material: Sets and displays the type of material the user set within III.-A.-5.-[\[b.Material Settings\]](#) in the designated channel.
- Use Homogenizer: When selected, automatically performs pipetting of the material within the channel to help prevent material or cells from clumping.
- Temperature: Allows the user to set the temperature of the designated channel.
- Set Temperature: When selected, changes and maintains the channel temperature.

[Channel Type Dropdown]

None

None

Droplet

Extrusion

Hi-Viscosity Extrusion(Hi-Temp.)

Hi-Viscosity Extrusion(Mid-Temp.)

Filament Extruder

[Material Dropdown]

Chocolate

Collagen

FB-medium

Fibrinogen

Gelatine

GelMA

KC-medium

MC-medium

MEL

NaHCO3

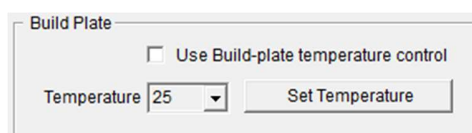
PCL

Pluronic F-127

Thrombin

d. Build-plate

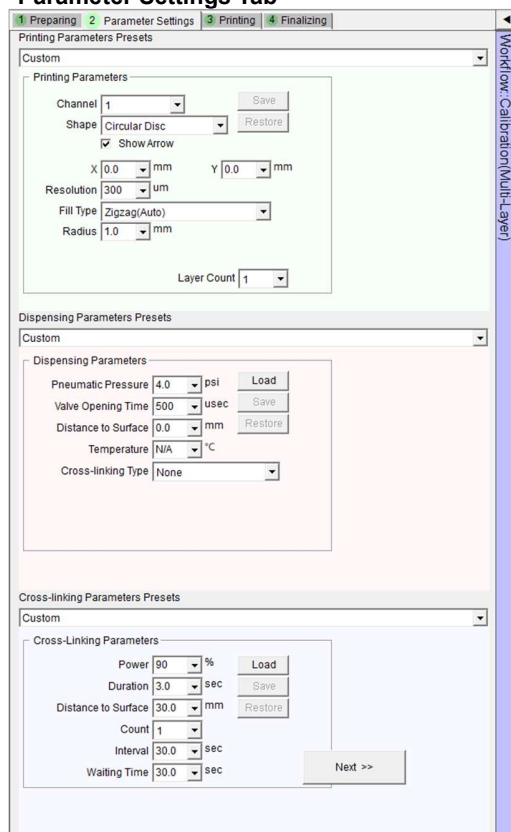
Function that allows the user to set the build-plate's temperature.



The 'Build Plate' dialog box contains a checkbox labeled 'Use Build-plate temperature control'. Below it, there is a 'Temperature' dropdown menu currently set to '25' and a 'Set Temperature' button.

- Use Build-plate temperature control: When selected, the user can access the build-plate temperature control function.
- Temperature: Allows the user to set the temperature of the build-plate.
- Set Temperature: When selected, changes the channel temperature to the desired temperature setting.

2. Parameter Settings Tab



The screenshot shows the 'Parameter Settings' tab with four sections: 'Printing Parameters Presets', 'Dispensing Parameters Presets', 'Cross-linking Parameters Presets', and a 'Next >>' button. The 'Printing Parameters' section includes fields for Channel (1), Shape (Circular Disc), Show Arrow (checked), X (0.0 mm), Y (0.0 mm), Resolution (300 um), Fill Type (Zigzag/Auto), Radius (1.0 mm), and Layer Count (1). The 'Dispensing Parameters' section includes Pneumatic Pressure (4.0 psi), Valve Opening Time (500 usec), Distance to Surface (0.0 mm), Temperature (N/A °C), and Cross-linking Type (None). The 'Cross-linking Parameters' section includes Power (90 %), Duration (3.0 sec), Distance to Surface (30.0 mm), Count (1), Interval (30.0 sec), and Waiting Time (30.0 sec).

The following options are displayed when pressing the 2. Parameter Settings button.

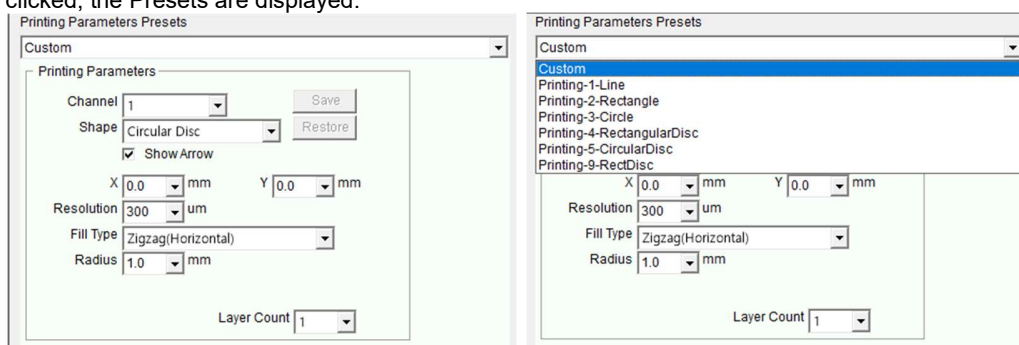
- a. Printing Parameters
- b. Dispensing Parameters
- c. Cross-linking Parameters

When everything is set, the user can press the Next button to enter 3. Printing

- Load : Load a set of previously saved printing parameters.
- Save : Save the parameters as a Preset (user-defined parameters saved as User Data Files)
- Restore : Load the default parameter values.

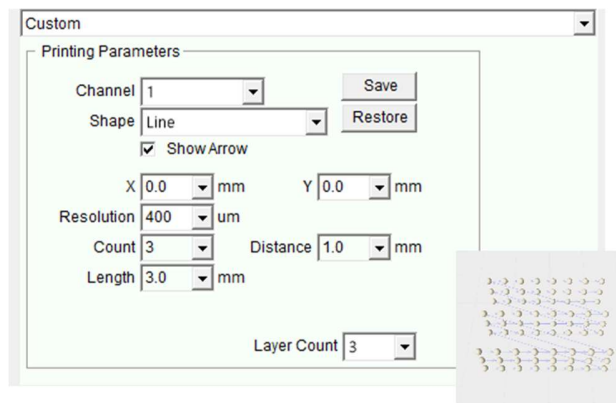
a. Printing Parameters

Allows the user to set the Printed shape and Fill Type. The Printing Parameters set by the user are displayed in real-time through the Model Viewer. After the setting is complete, the user can save the parameters as a Preset (user-defined parameters saved as User Data Files). When the Custom button is clicked, the Presets are displayed.



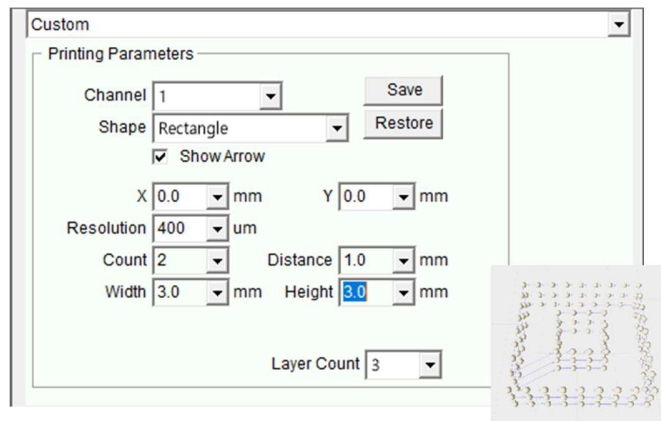
The 'Printing Parameters Presets' dialog box shows a list of presets on the left: Custom, Printing-1-Line, Printing-2-Rectangle, Printing-3-Circle, Printing-4-RectangularDisc, Printing-5-CircularDisc, and Printing-9-RectDisc. The 'Custom' preset is selected, and its parameters are displayed on the right: Channel (1), Shape (Circular Disc), Show Arrow (checked), X (0.0 mm), Y (0.0 mm), Resolution (300 um), Fill Type (Zigzag(Horizontal)), Radius (1.0 mm), and Layer Count (1).

1) Shape - Line



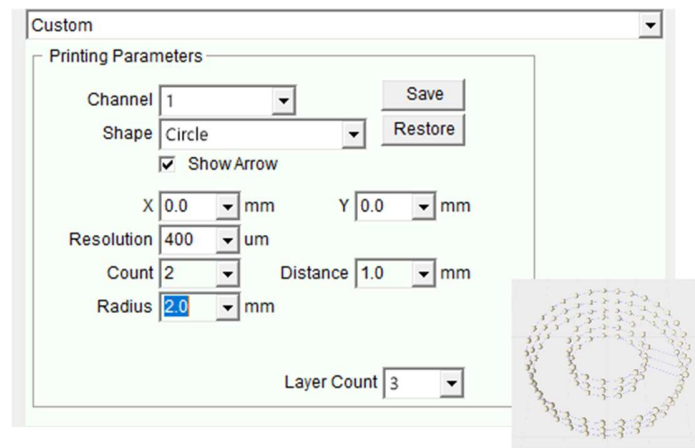
- Channel: The user can select a channel
- Shape[Line]: When selected, the material is printed as a line (see the inset of the above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets. (Printing spatial resolutions)
- Count: The user can choose the number of lines that will be printed.
- Distance: The user can choose the gap between the printed lines.
- Length: The user can choose the length of a printed line.
- Layer counts: The user defines the number of layers to be printed.

2) Shape – Rectangle



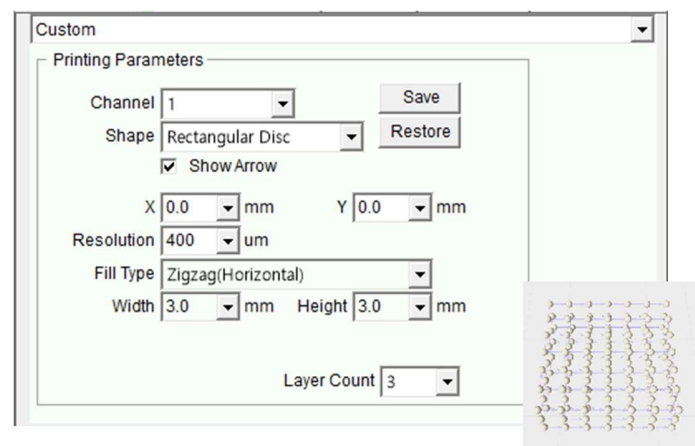
- Channel: The user can select a channel.
- Shape[Rectangle]: When selected, the material is printed as a rectangle (see the inset of the above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Count: The user can choose the number of rectangles that will be printed.
- Distance: The user can choose the gap between the printed rectangles.
- Width: The user can choose the printed rectangle's outer width.
- Height: The user can choose the printed rectangle's outer height.
- Layer counts: The user defines the number of layers to be printed.

3) Shape – Circle



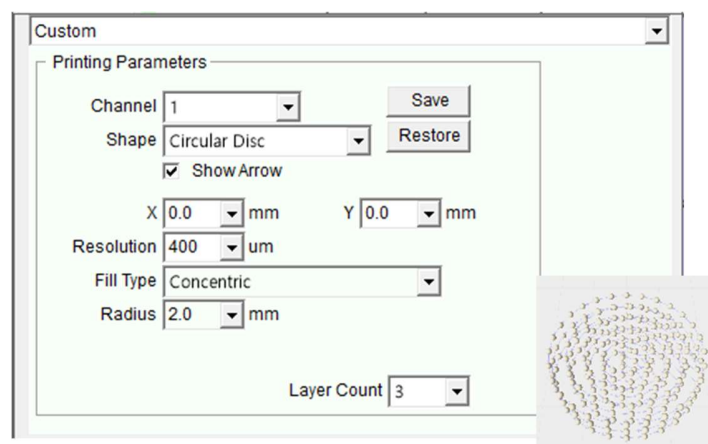
- Channel: The user can select a channel.
- Shape[Circle]: When selected, the material is printed as a circle (see the inset of the above figure).
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Count: The user can choose the number of circles that will be printed.
- Distance: The user can choose the gap between the printed circles.
- Radius: The user can choose the radius of the outer circle.
- Layer counts: The user defines the number of layers to be printed.

4) Shape - Rectangular Disc



- Channel: The user can select a channel.
- Shape[Rectangular Disc]: When selected, the material is printed as a filled rectangle
- Show Arrow: When selected, the printing Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Fill Type: The user can choose how they will fill in the rectangle. (See the information below regarding 'Fill Type')
- Width: The user can choose the rectangle's width.
- Height: The user can choose the rectangle's height.
- Layer counts: The user defines the number of layers to be printed.

5) Shape – Circular Disc



- Channel: The user can select a channel.
- Shape[Circular Disc]: When selected, the material is printed as a filled circle.
- Show Arrow: When selected, the Directions and sequences are displayed in the Model Viewer image.
- X/Y: The user can choose the central coordinates for printing.
- Resolution: The user can choose the distance between the printed Droplets.
- Fill Type: The user can choose how they will fill in the circle. (See the information below regarding 'Fill Type')
- Radius: The user can define the outer-most radius.
- Layer counts: The user defines the number of layers to be printed.

- Fill Type: Ungreyed when selecting Rectangular Disc/Circle Disc. Allows the user to choose how they will fill the rectangle or circle

Zigzag(Horizontal) : Fills in by going top to bottom, in a zigzag pattern.	Zigzag(Vertical) : Fills in by going left to right, in a zigzag pattern.	Concentric : Fills in by going from the outer diameter to the center
Gradient Rate : 0% : Fills in with a spatial gradient by going from the outer diameter to the center	Gradient Rate : 50% : Fills in with a spatial gradient by going from the outer diameter to the center	Gradient Rate : 100% : Fills in with a spatial gradient by going from the outer diameter to the center

b. Dispensing Parameters

Allows the user to set the parameters regarding dispensing.

Dispensing Parameters Presets

Custom

Dispensing Parameters

Pneumatic Pressure: 5.0 psi

Valve Opening Time: 500 usec

Distance to Surface: 0.0 mm

Temperature: N/A °C

Cross-linking Type: Nebulizer

Nebulizer Channel: 1

Load, Save, Restore buttons

- Pneumatic Pressure: Allows the user to set the applied pneumatic pressure to the channel.
- Valve Opening Time: Function that allows the user to set the amount of time the valve is open. While the valve is open, the material is printed.
- Distance to Surface: The user can set the height at where printing begins.
- Temperature: The user can set each channel's temperature. If the user has already set the temperature in the 'preparing' tab, they can select N/A. If the temperature setting needs revision, the user selects a new temperature.
- Cross-linking Type: The user can select the appropriate Cross-linking method.

1) UV-LED(per Droplet)

: When one droplet is dispensed, UV-LEDs (located below the channel) irradiate the droplet. The user can change the duration of UV-LED irradiation from 'UV Irradiation Time'.

2) UV-LED(per Layer)

: When a single layer is fully printed, the UV-LED then irradiates the entire layer. The user can change the duration of UV-LED irradiation from 'UV Irradiation Time'.

3) Nebulizer

: The Nebulizer settings menu will be displayed (See c. Cross-linking Parameter)

4) UV-Lamp

: The user can change how long the UV-Lamp(Omniculture)is turned on.

c. Cross-linking Parameters

Displayed when the user selects the Nebulizer as the Cross-linking Type from the Dispensing Parameters. It sets the operating parameters of the Nebulizer.

Cross-linking Parameters Presets

Custom

Cross-Linking Parameters

Power: 100 %

Duration: 3.0 sec

Distance to Surface: 30.0 mm

Count: 1

Interval: 30.0 sec

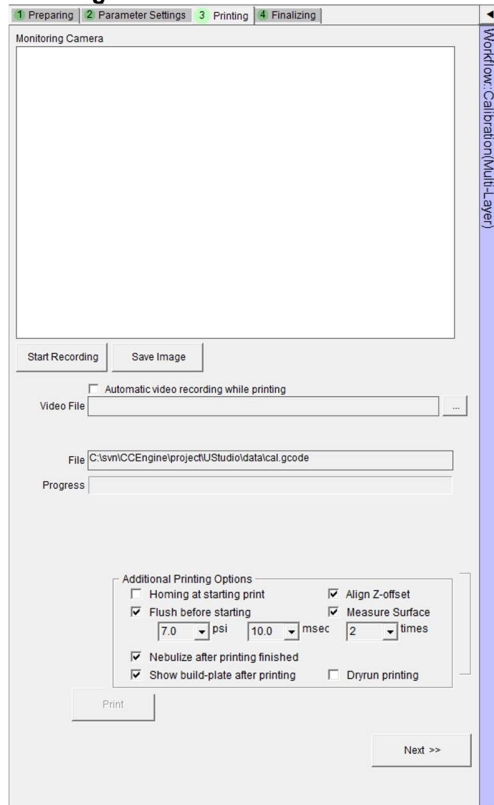
Waiting Time: 30.0 sec

Load, Save, Restore buttons

Next >> button

- Power: The user can choose the amount of nebulizing power as a percentage.
- Duration: The user can choose the duration of nebulization.
- Distance to Surface: The user can choose the height from the bioware at where the Nebulizer works.
- Count: The user can choose how many times the Nebulizer dispenses the crosslinking material.
- Interval: The user can choose the interval at which the Nebulizer dispenses, if the Nebulizer is continuously dispensing.
- Waiting Time: The user can choose the waiting period after nebulization and before printing so that proper crosslinking will be ensured. (i.e. crosslinking time may vary depending on the type and concentration of specific material),

3. Printing Tab



When the user presses the 3. Printing button, a menu that allows the user to execute Multi-Layer Calibration.

- a. Monitoring Camera
- b. Progress
- c. Additional Printing Options
- d. Report

When everything is set, the user can press the Next button to enter 4. Finalizing.

a. Monitoring Camera

The Monitoring Camera takes video/pictures of the printing process in real-time. The user can archive the printing process as a video or image file.

- Automatic video recording while printing: When selected, the Monitoring Camera automatically films the printing process when it starts. (saves as .mp4)
- Start Recording: When selected, manually begins filming the printing process. (saves as .mp4)
- Save Image: When selected, a screenshot is saved (as .png)
- Video File: When the user presses the '...' button, they can choose the directory to save the video/image files.

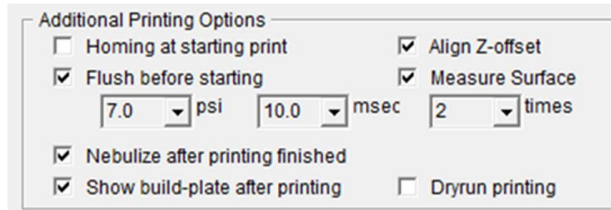
b. Printing Status

Displays information about the printing process in real-time.

- File : Displays the location of the file that is being printed.
- Progress : Displays the completion of the printing process as a Bar graph.
- Layer : Displays the current number of material layers.
- Current Job : If the printing process has not finished, Current Job displays as 'Printing'. If it is finished, it displays as 'Finished'.
- Start Time : Displays the time when the printing process began.
- Finish Time : Displays the time when the printing process will finish.
- Elapsed Time : Displays the amount of time left before the printing process concludes.
- Print / Pause : When the user presses the Print button, the printing process begins, and the Print button changes to the Pause button. When the user presses the Pause button, the printing process can be temporarily stopped.
- Resume : Appears when the Pause button is pressed. When clicked, it resumes the printing process.
- Cancel : Appears when the Pause button is pressed. When clicked, it terminates the printing process.

c. Additional Printing Options

Allows the user to select additional features for printing.



Additional Printing Options

☐ Homing at starting print ☒ Align Z-offset

☒ Flush before starting ☒ Measure Surface

7.0 psi 10.0 msec 2 times

☒ Nebulize after printing finished

☒ Show build-plate after printing ☐ Dryrun printing

- Homing at starting print: When selected, the build-plate moves to the Initial reference position of the U-FAB before the printing process begins.
- Align Z-offset: When selected, the build plate undergoes processes that adjust the vertical offset from the nozzle.
- Measure Surface: When selected, the distance between the buildplate and the nozzle is measured.
- Flush before starting: When selected, the channels are flushed before the printing process begins.
- Nebulize after printing finished:
- Show buile-plate after printing: When selected, the build-plate moves to the front panel of the U-FAB after the printing process finishes. When unselected, the build-plate stops at the location where the printing process finished.
- Dryrun printing: When selected, the users can simulate the entire printing process without dispensing any materials.

4. Finalizing Tab

Workflow: Calibration(Multi-Layer)

1 Preparing 2 Parameter Settings 3 Printing 4 Finalizing

Printing/Slicing Parameters

Printing Parameters:

Material Channel: 0
X: 0
Y: 0
Spatial resolution: 300 um
Shape: Circular Disc
Radius: 1 mm

Save Parameters

Dispensing Parameters

Dispensing Parameters:

Pneumatic pressure: 4 psi
Valve opening time: 500 usec
Distance to surface: 0 mm
Temperature: N/A

Save Parameters

Cross-Linking Parameters

Cross-linking Parameters:

Nebulizing Power: 90 %
Duration: 3 sec
Distance to surface: 30 mm
Nebulizing Count: 1
Interval: 30 sec
Waiting time: 30 sec

Save Parameters

When the user presses the 4. Finalizing button, the parameters set during Multi-Layer Calibration are displayed. The user can verify and save these parameters from the Finalizing Tab

- a. **Printing/Slicing Parameters**
- b. **Dispensing Parameters**
- c. **Cross-Linking Parameters**

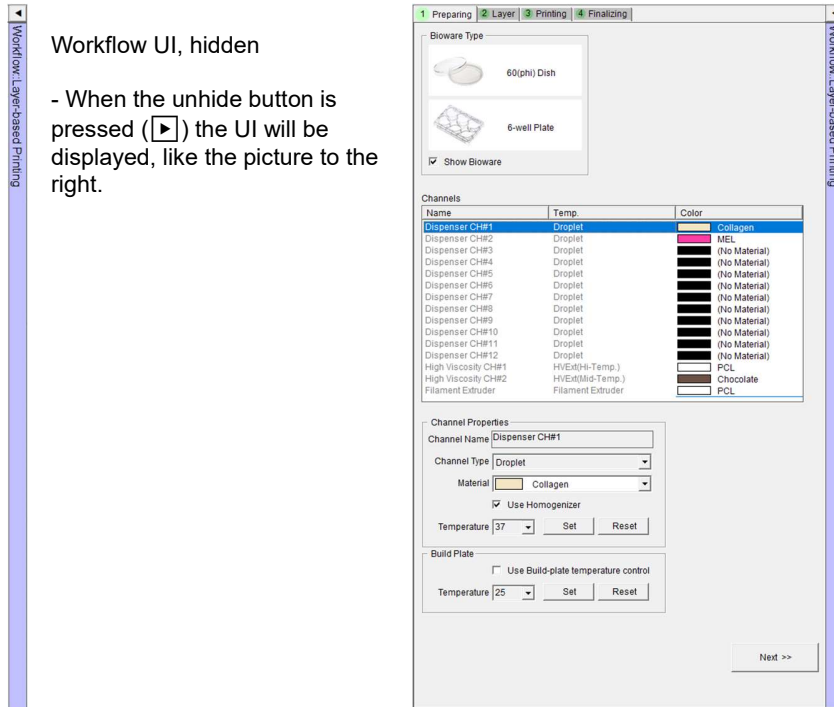
- Save Parameters: If the user presses the Save Parameters button, the parameters displayed under the Finalizing Tab are saved.

- a. **Printing/Slicing Parameters**
The user can verify and save the Printing/Slicing Parameters.
- b. **Dispensing Parameters**
The user can verify and save the Dispensing Parameters.
- c. **Cross-Linking Parameters**
The user can verify and save the Cross-Linking Parameters

C3. Workflow UI – Layer-Based Printing

Workflow UI is a menu that is displayed at the bottom of the Main Window's left Icon Bar. When the user presses the Layer-based Printing button from the Welcome Window, the corresponding Workflow UI will be displayed on the Main Window.

The Workflow UI for Layer-based printing is composed of 1. Preparing, 2. Layer, 3. Printing, and 4. Finalizing menus. The user can use the hide button(◀)or the unhide button(▶)to hide or unhide the Workflow UI.



- If the user hides the Workflow UI, they can enlarge the III.-[D.Model Viewer] window.

1. Preparing Tab

Bioware Type

60(phi) Dish

6-well Plate

☒ Show Bioware

Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	MEL
Dispenser CH#3	Droplet	(No Material)
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Chocolate
Filament Extruder	Filament Extruder	PCL

Channel Properties

Channel Name: Dispenser CH#1

Channel Type: Droplet

Material: Collagen

☒ Use Homogenizer

Temperature: 37 Set Reset

Build Plate

☐ Use Build-plate temperature control

Temperature: 25 Set Reset

Next >>

The following options are displayed when pressing the 1. Preparing button.

- a. Bioware Type
- b. Channels
- c. Channel Properties
- d. Build Plate

When everything is set, the user can press the Next button to enter 2. Layer tab.

a. Bioware Type

Bioware Type

60(phi) Dish

6-well Plate

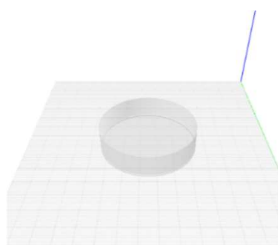
☒ Show Bioware

Target Well

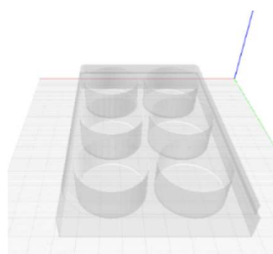
Printing Target: 1

The user can select the 60(phi) Dish (60mm inner diameter) or 6-well Plate (each 35mm inner diameter) to designate which bioware to run Calibration process.

- Show Bioware: When selected, this displays the designated Bioware in the Model Viewer.
- Target Well: The user can designate the location of the well (#1~6) from the 6-well Plate where the printing occurs.



60(phi) Dish



6-well Plate

b. Channels

Displays name and type of Channels used in the U-FAB. The user can select each channel to change Channel Properties.

Channels		
Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	MEL
Dispenser CH#3	Droplet	(No Material)
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Chocolate
Filament Extruder	Filament Extruder	PCL

- Displayed information: Channel name / Channel type / Materials used / Material color within the Model Viewer
- Because the U-STUDIO cannot detect the materials used within each channel of the U-FAB, the user must check if the materials loaded into each U-FAB channel matches with the material displayed in the U-STUDIO channel.

c. Channels Properties

Function that sets the Properties of the designated channel.

Channel Properties

Channel Name
Dispenser CH#1

Channel Type
Droplet

Material
Collagen

☒ Use Homogenizer

Temperature
37
Set
Reset

- Channel Name: Displays the name of the designated channel.
- Channel Type: Sets the channel type of the designated channel.
- Material: Sets and displays the type of material the user set within III.-A.-5.-[\[b.Material Settings\]](#) in the designated channel.
- Use Homogenizer: When selected, automatically performs pipetting of the material within the channel to help prevent material or cells from clumping.
- Set: When selected, changes and maintains the channel temperature
- Reset: When selected, disengages from temperature control

[Channel Type Dropdown]

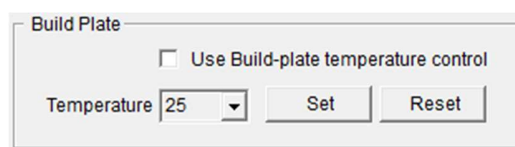
None
Droplet
Extrusion
Hi-Viscosity Extrusion(Hi-Temp.)
Hi-Viscosity Extrusion(Mid-Temp.)
Filament Extruder

[Material Dropdown]

Chocolate
Collagen
FB-medium
Fibrinogen
Gelatine
GelMA
KC-medium
MC-medium
MEL
NaHCO3
PCL
Pluronic F-127
Thrombin

d. Build Plate

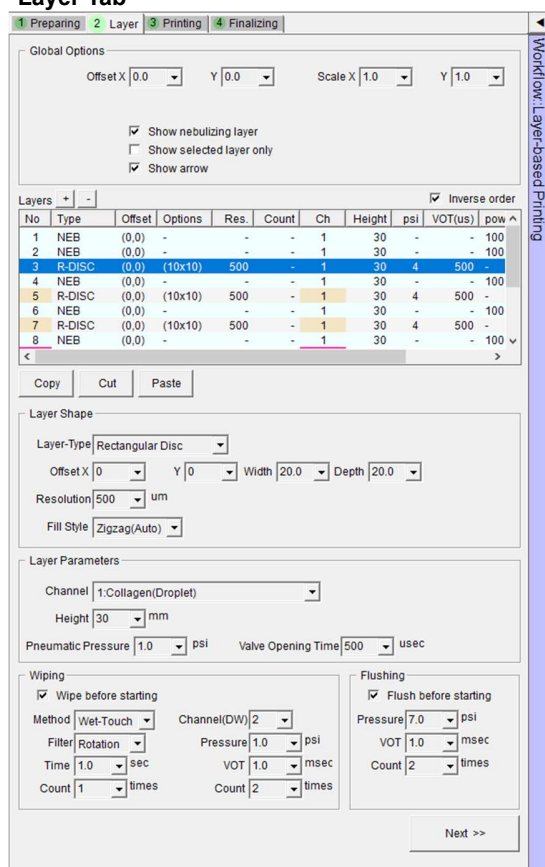
Function that allows the user to set the build-plate's temperature.



The Build Plate dialog box contains a checkbox labeled "Use Build-plate temperature control". Below it is a "Temperature" field with a dropdown menu showing "25". To the right of the field are two buttons: "Set" and "Reset".

- Use Build-plate temperature control: When selected, the user can access the build-plate temperature control function.
- Temperature: Allows the user to set the temperature of the build-plate.
- Set: When selected, changes the channel temperature to the desired temperature setting.
- Reset: When selected, disengages from temperature control

2. Layer Tab



The Layer Tab interface is divided into several sections. At the top, there are "Global Options" with fields for "Offset X", "Y", "Scale X", and "Y", each with a dropdown menu. Below these are three checkboxes: "Show nebulizing layer", "Show selected layer only", and "Show arrow". A "Layers" table is displayed, showing a list of layers with columns for No, Type, Offset, Options, Res., Count, Ch, Height, psi, VOT(us), and pow. Below the table are "Copy", "Cut", and "Paste" buttons. The "Layer Shape" section includes a "Layer-Type" dropdown (set to "Rectangular Disc"), "Offset X", "Y", "Width", and "Depth" fields, a "Resolution" field (set to "500 um"), and a "Fill Style" dropdown (set to "Zigzag(Auto)"). The "Layer Parameters" section has a "Channel" dropdown (set to "1:Collagen(Droplet)", "Height" field (set to "30 mm"), "Pneumatic Pressure" field (set to "1.0 psi"), and "Valve Opening Time" field (set to "500 usec"). The "Wiping" section has a "Wipe before starting" checkbox, "Method" dropdown (set to "Wet-Touch"), "Channel(DW)" dropdown (set to "2"), "Filter" dropdown (set to "Rotation"), "Time" field (set to "1.0 sec"), "Count" field (set to "1 times"), "Pressure" field (set to "1.0 psi"), "VOT" field (set to "1.0 msec"), and "Count" field (set to "2 times"). The "Flushing" section has a "Flush before starting" checkbox, "Pressure" field (set to "7.0 psi"), "VOT" field (set to "1.0 msec"), and "Count" field (set to "2 times"). A "Next >>" button is at the bottom right.

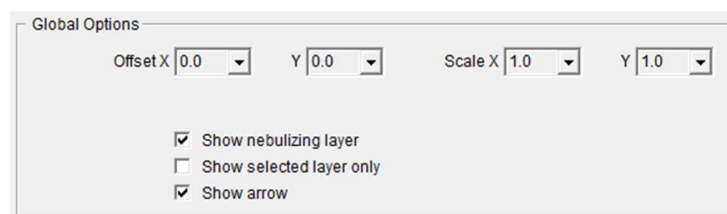
The following options are displayed when pressing the 2. Layer button.

- a. Global Options
- b. Layers
- c. Layer Shape
- d. Layer Parameters
- e. Wiping/Flushing

When everything is set, the user can press the Next button to enter 3. Printing process.

a. Global Options

Users can move or set scaling factor of the layers. It can also control the layer-specific labeling options.



The Global Options dialog box shows fields for "Offset X", "Y", "Scale X", and "Y", each with a dropdown menu. Below these are three checkboxes: "Show nebulizing layer", "Show selected layer only", and "Show arrow".

- Offset X, Y: Move the entire layers to X,Y direction (in mm).
- Scale X, Y: Set scaling factor for dimension of the entire layers.
- Show nebulizing layer: Display layer having nebulization.
- Show selected layer only: Select the layer(s) to be displayed.
- Show arrow: Select if the user wants to visualize the printing direction per each layer (via arrows).

c. Layer Shape

The users edits and display type, shape, resolution paramters for each laye. Once edited, it automatically updates the listed content.

Layer Shape

Layer-Type
Rectangular Disc

Offset X
0.0
Y
0.0
Width
20.0
Depth
20.0

Resolution
500
um

Fill Style
Zigzag(Auto)

Layer-Type Dropdown	Fill Style Dropdown
<div> Rectangular Disc Circular Disc Rectangular Rim Circular Rim Nebulize UV LED OMNICURE </div>	<div> Zigzag(Auto) Zigzag(H) Zigzag(V) Concentric Gradient </div>

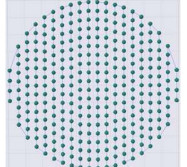
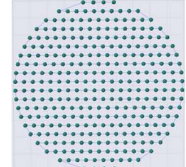
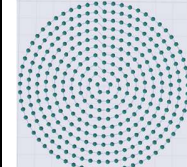
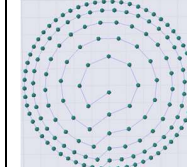
- Layer-Type: Defines the type of layer.
The list of variables when Layer-Type is selected.

Rectangular Disc	Offset X 0 Y 0 Radius 5.0 Resolution 500 um Fill Style Zigzag(Auto)
Cicular Disc	Offset X 0 Y 0 Radius 5.0 Resolution 500 um Fill Style Zigzag(Auto)
Rect-Rim	Offset X 0 Y 0 Width 10 Depth 10 Resolution 500 um Rim Count 1
Circ-Rim	Offset X 0 Y 0 Radius 5.0 Resolution 500 um Rim Count 1
Nebulize UV LED OMNICURE	Offset X 0 Y 0

- Offset X, Y: Define the location of the printing (at center locations)
* The coordinate (0,0) represent the center of the printed layer.
- Width: Defines the width of a rectangular layer in 3D.
- Depth: Defines the depth of a rectangular layer in 3D.
- Radius: Defines the radius of circular layer.
- Resolution: Define the spatial distance between droplet dispensing.
- Rim Count: In case of Rim-like structure, defines the number of rim.

Rim Count: 0	Rim Count: 1	Rim Count: 2	Rim Count: 3	Rim Count: 4
None				

- Fill Style : Defines the filling pattern in rectangular/circular disc.

Zigzag(Auto)	Zigzag(H)	Zigzag(V)	Concentric	Gradient
None				

* Zigzag(Auto) : Automatic generation of zigzag patterns in either horizontal (H) or vertical (V) direction.

d. Layer Parameters

Allows the user to set the parameters regarding dispensing and crosslinking paramters for each layer.

[Layer Type]: Rectagular Disc Circular Disc Rectagular Rim Circular Rim	Layer Parameters Channel: 1:Collagen(Droplet) Height: 30 mm Pneumatic Pressure: 1.0 psi Valve Opening Time: 400 usec
[Layer Type]: Nebulize	Layer Parameters Channel: Nebulizer#1 Height: 30 mm Power: 100 % Time: 3 sec Wait: 30 sec
[Layer Type]: UV LED	Layer Parameters Channel: 1:Dispenser CH#1(Droplet) Height: 30 mm Time: 3 sec Wait: 30 sec
[Layer Type]: OMNICURE	Layer Parameters Channel: N/A Height: 30 mm Time: 3 sec Wait: 30 sec

- Channel: Select and edit the corresponding layer.
- Height: Adjust the height of the layer.
- Pneumatic Pressure: Allows the user to set the amount of pneumatic pressure within the valve.
- Valve Opening Time: Function that allows the user to set the amount of time the valve is open. While the valve is open, the material is printed.
- Power: Adjust the power setting
- Time: Adjust the operational time
- Wait: Defines the wait time between the operation.

e. Wiping/Flushing

Allows to edit the parameter for wiping/flushing for each layer.

[V] Wipe before starting : Select if the user wants to use the wiping feature.

- Method : (Touch/Rub/Wet-Touch)

Touch: The nozzle touches the filter surface.

Rub: The nozzle rub against the filter surface for set period of time.

Wet-Touch: Same with touch, but uses the wet filter surface by dispensing distilled water (DW) onto the filter.

- Filter : Choose the mode of wiping (Rotation/1/2/3/4/5/6/7/8/9) * Rotation enables automatic rotation of the filter location.

- Time : Set the wiping duration.

- Count : Set the number of wiping per each layer.

- Channel(DW) : Activated when Wet-Touch is selected. It enables the channels that contains DW to wet the filter.

- Pressure : Activated when Wet-Touch is selected. Defines the applied pneumatic pressure for the DW dispensing.

- VOT : Activated when Wet-Touch is selected. Defines the VOT of the corresponding channel.

- Count : Activated when Wet-Touch is selected. Defines the number of dispensing from the corresponding channel

[V] Flush before starting : Prior to layer printing, the user can choose whether to engage flushing capability (to wet the nozzle)

- Pressure : Defines the applied pneumatic pressure

- VOT : Defines the VOT of the corresponding channel.

- Count : Defines the number of flushing.

3. Printing Tab

When the user presses the 3. Printing button, a menu appears so that the user can execute Printing with the parameters set through 1. Preparing and 2. Layer settings.

a. Monitoring Camera

b. Progress

c. Additional Printing Options

d. Report

When everything is set, the user can press the Next button to enter 4. Finalizing.

a. Monitoring Camera

The Monitoring Camera takes video/pictures of the printing process in real-time. The user can archive the printing process as a video or image file.

- Automatic video recording while printing: When selected, the Monitoring Camera automatically films the printing process when it starts. (saves as .mp4)
- Start Recording: When selected, manually begins filming the printing process. (saves as .mp4)
- Save Image: When selected, a screenshot is saved (as .png)
- Video File: When the user presses the '...' button, they can choose the directory to save the video/image files.

b. Printing Status

Displays information about the printing process in real-time.

- File : Displays the location of the file that is being printed.
- Progress : Displays the completion of the printing process as a Bar graph.
- Layer : Displays the current number of material layers.
- Current Job : If the printing process has not finished, Current Job displays as 'Printing'. If it is finished, it displays as 'Finished'.
- Start Time : Displays the time when the printing process began.
- Finish Time : Displays the time when the printing process will finish.
- Elapsed Time : Displays the amount of time left before the printing process concludes.
- Print / Pause : When the user presses the Print button, the printing process begins, and the Print button changes to the Pause button. When the user presses the Pause button, the printing process can be temporarily stopped.
- Resume : Appears when the Pause button is pressed. When clicked, it resumes the printing process.
- Cancel : Appears when the Pause button is pressed. When clicked, it terminates the printing process.

c. Additional Printing Options

Allows the user to select additional features for printing.

Additional Printing Options

<input type="checkbox"/> Homing at starting print	<input checked="" type="checkbox"/> Align Z-offset
<input checked="" type="checkbox"/> Flush before starting	<input checked="" type="checkbox"/> Measure Surface
<input type="text" value="7.0"/> psi	<input type="text" value="10.0"/> msec
<input checked="" type="checkbox"/> Nebulize after printing finished	<input type="text" value="2"/> times
<input checked="" type="checkbox"/> Show build-plate after printing	<input type="checkbox"/> Dryrun printing

- Homing at starting print: When selected, the build-plate moves to the Initial reference position of the U-FAB before the printing process begins.
- Align Z-offset: When selected, the build plate undergoes processes that adjust the vertical offset from the nozzle.
- Measure Surface: When selected, the distance between the buildplate and the nozzle is measured.
- Flush before starting: When selected, the channels are flushed before the printing process begins.
- Nebulize after printing finished:
- Show buile-plate after printing: When selected, the build-plate moves to the front panel of the U-FAB after the printing process finishes. When unselected, the build-plate stops at the location where the printing process finished.
- Dryrun printing: When selected, the users can simulate the entire printing process without dispensing any materials.

4. Finalizing Tab

Workflow: Layer-based Printing

1 Preparing 2 Layer 3 Printing 4 Finalizing

Printing/Slicing Parameters

Save Parameters

Dispensing Parameters

Save Parameters

Cross-Linking Parameters

Save Parameters

When the user presses the 4. Finalizing button, the parameters set during Model-based printing are displayed. The user can verify and save these parameters from the Finalizing Tab.

- a. **Printing/Slicing Parameters**
- b. **Dispensing Parameters**
- c. **Cross-Linking Parameters**

- Save Parameters: If the user presses the Save Parameters button, the parameters displayed under the Finalizing Tab are saved.

a. **Printing/Slicing Parameters**

The user can verify and save the Printing/Slicing Parameters.

b. **Dispensing Parameters**

The user can verify and save the Dispensing Parameters.

c. **Cross-Linking Parameters**

The user can verify and save the Cross-Linking Parameters

C4. Workflow UI – Model-based printing

Workflow UI is a menu that is displayed at the bottom of the Main Window's left Icon Bar. When the user presses the Model-based Printing button from the Welcome Window, the Workflow UI for Model-Based Printing will be displayed on the Main Window.

The Workflow UI for Model-based printing is composed of 1. Preparing, 2. Modeling, 3. Parameter Setting, 4. Printing, and 5. Finalizing menus. The user can use the hide button(◀) or the unhide button(▶) to hide or unhide the Workflow UI.

Workflow Model-based Printing

Workflow UI, hidden

- When the unhide button is pressed (▶) the UI will be displayed, like the picture to the right.

Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	GelMA
Dispenser CH#3	Droplet	(No Material)
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Pluronic F-127
Filament Extruder	Filament Extruder	PCL

Workflow UI, in display

- When the hide button is pressed (◀) the UI will be hidden, like the picture to the left.

- If the user hides the Workflow UI, they can enlarge the III.-[D.Model Viewer] window.

1. Preparing Tab

Bioware Type

60(phi) Dish

6-well Plate

☒ Show Bioware

Name	Temp.	Color
Dispenser CH#1	Droplet	Collagen
Dispenser CH#2	Droplet	GelMA
Dispenser CH#3	Droplet	(No Material)
Dispenser CH#4	Droplet	(No Material)
Dispenser CH#5	Droplet	(No Material)
Dispenser CH#6	Droplet	(No Material)
Dispenser CH#7	Droplet	(No Material)
Dispenser CH#8	Droplet	(No Material)
Dispenser CH#9	Droplet	(No Material)
Dispenser CH#10	Droplet	(No Material)
Dispenser CH#11	Droplet	(No Material)
Dispenser CH#12	Droplet	(No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	PCL
High Viscosity CH#2	HVExt(Mid-Temp.)	Pluronic F-127
Filament Extruder	Filament Extruder	PCL

Channel Properties

Channel Name: Dispenser CH#1

Channel Type: Droplet

Material: Collagen

☒ Use Homogenizer

Temperature: 37 Set Reset

Build Plate

☐ Use Build-plate temperature control

Temperature: 25 Set Reset

The following options are displayed when pressing the 1. Preparing button.

- a. Bioware Type
- b. Channels
- c. Channel Properties
- d. Build-plate

When everything is set, the user can press the Next button to enter 2. Parameter Settings.

a. Bioware Type

Bioware Type

60(phi) Dish

6-well Plate

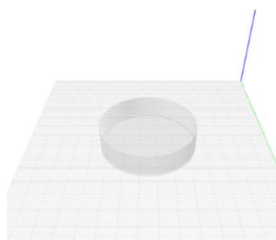
☒ Show Bioware

Target Well

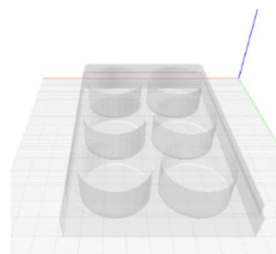
Printing Target: 1

The user can select the 60(phi) Dish (60mm inner diameter) or 6-well Plate (each 35mm inner diameter) to designate which bioware to run Calibration process.

- Show Bioware: When selected, this displays the designated Bioware in the Model Viewer.
- Target Well: The user can designate the location of the well (#1~6) from the 6-well Plate where the printing occurs.


















60(phi) Dish



6-well Plate

b. Channels

Displays name and type of Channels used in the U-FAB. The user can select each channel to change Channel Properties.

Channels		
Name	Type	Color(Material)
Dispenser CH#1	Droplet	 Collagen
Dispenser CH#2	Droplet	 Collagen
Dispenser CH#3	Droplet	 Gelatine
Dispenser CH#4	Droplet	 (No Material)
Dispenser CH#5	Droplet	 (No Material)
Dispenser CH#6	Droplet	 (No Material)
Dispenser CH#7	Droplet	 (No Material)
Dispenser CH#8	Droplet	 (No Material)
Dispenser CH#9	Droplet	 (No Material)
Dispenser CH#10	Droplet	 (No Material)
Dispenser CH#11	Droplet	 (No Material)
Dispenser CH#12	Droplet	 (No Material)
High Viscosity CH#1	HVExt(Hi-Temp.)	 (No Material)
High Viscosity CH#2	HVExt(Mid-Temp.)	 (No Material)
Filament Extruder	Filament Extruder	 (No Material)

- Displayed information: Channel name / Channel type / Materials used / Material color within the Model Viewer
- Because the U-STUDIO cannot detect the materials used within each channel of the U-FAB, the user must check if the materials loaded into each U-FAB channel matches with the material displayed in the U-STUDIO channel.


c. Channel Properties

Function that sets the Properties of the designated channel.

Channel Properties

Channel Name
Dispenser CH#1

Channel Type
Droplet

Material
 Collagen

☒ Use Homogenizer

Temperature
37
Set Temperature

- Channel Name: Displays the name of the designated channel.
- Channel Type: Sets the channel type of the designated channel.
- Material: Sets and displays the type of material the user set within III.-A.-5.-[\[b.Material Settings\]](#) in the designated channel.
- Use Homogenizer: When selected, automatically performs pipetting of the material within the channel to help prevent material or cells from clumping.
- Temperature: Allows the user to set the temperature of the designated channel.
- Set Temperature: When selected, changes and maintains the channel temperature.

[Channel Type Dropdown]

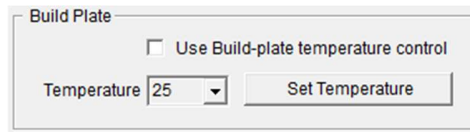
None
Droplet
Extrusion
Hi-Viscosity Extrusion(Hi-Temp.)
Hi-Viscosity Extrusion(Mid-Temp.)
Filament Extruder

[Material Dropdown]

Chocolate
Collagen
FB-medium
Fibrinogen
Gelatine
GelMA
KC-medium
MC-medium
MEL
NaHCO3
PCL
Pluronic F-127
Thrombin

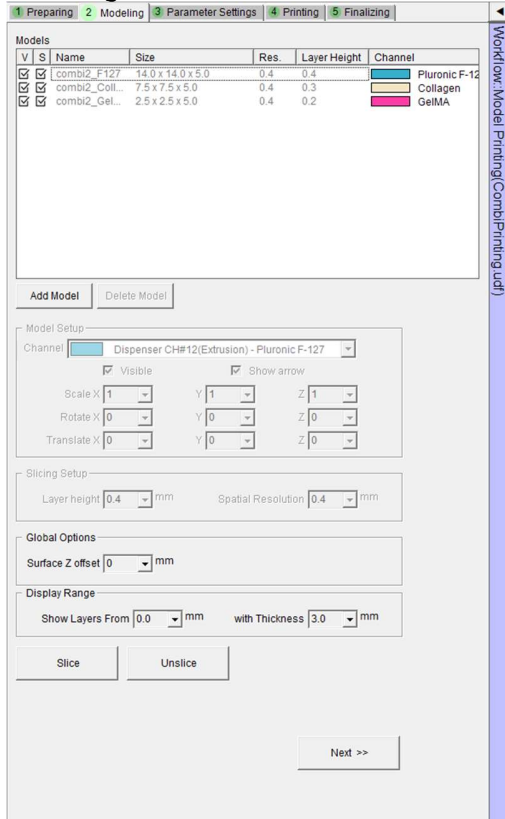
d. Build-plate

Function that allows the user to set the build-plate's temperature.



- Use Build-plate temperature control: When selected, the user can access the build-plate temperature control function.
- Temperature: Allows the user to set the temperature of the build-plate.
- Set Temperature: When selected, changes the channel temperature to the desired temperature setting.

2. Modeling Tab



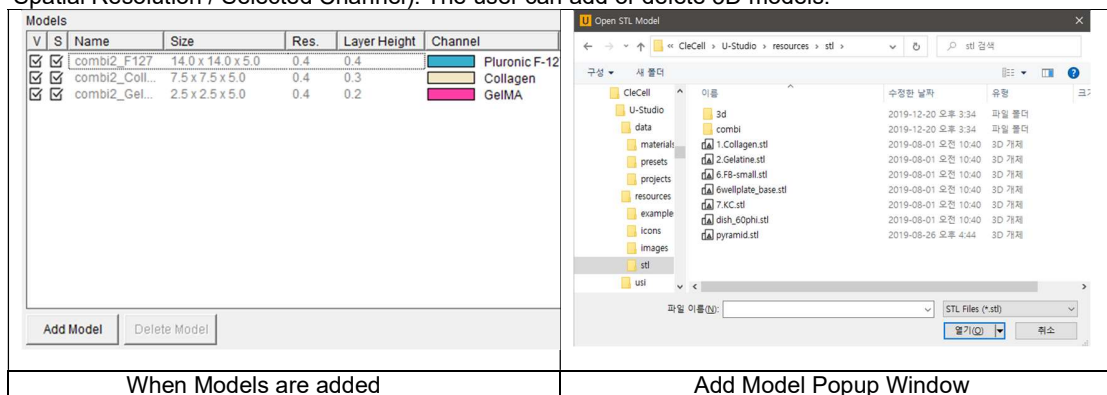
The following options are displayed when pressing the 2. Modeling button.

- Models
- Model Setup
- Slicing Setup
- Display Range

When everything is set, the user can press the Next button to enter 3. Parameter Settings.

a. Models

Displays the data of each 3D model the user selected (Visibility / Selectability / Model Size / Layer Height / Spatial Resolution / Selected Channel). The user can add or delete 3D models.



When Models are added

Add Model Popup Window

- Add Model : The user can add a model.
- Delete Model : The user can delete the selected model.
- Visible(V) : The 3D model is displayed in the Model Viewer when checkbox V is selected.
- Selectable(S) : The 3D model is selected in the Model Viewer when checkbox S is selected.
- Size : Displays the size of the 3D model.
- Resolution(Res.) : Displays the 2D Spatial Resolution of the 3D model.
- Layer Height : Displays the space between each layer of the 3D model.
- Channel : Displays data of the Channel that is designated to the 3D model.

b. Model Setup

The user can change the Scalar / Rotational / Translational values of the 3D model. The changes are displayed in real-time through the Model Viewer.

- Visible : When selected, the model is displayed through the Model Viewer.
- Show arrow : When selected, the directions and sequences are displayed in the Model Viewer image.
- Scale : The user can set the scalar value of the 3D model in X/Y/Z directions. (1.0 is the real-life size of the model.)
- Rotate : The user can set the rotational value of the in X/Y/Z axes.
- Translate : The user can set the translational value of the 3D model in X/Y/Z directions.

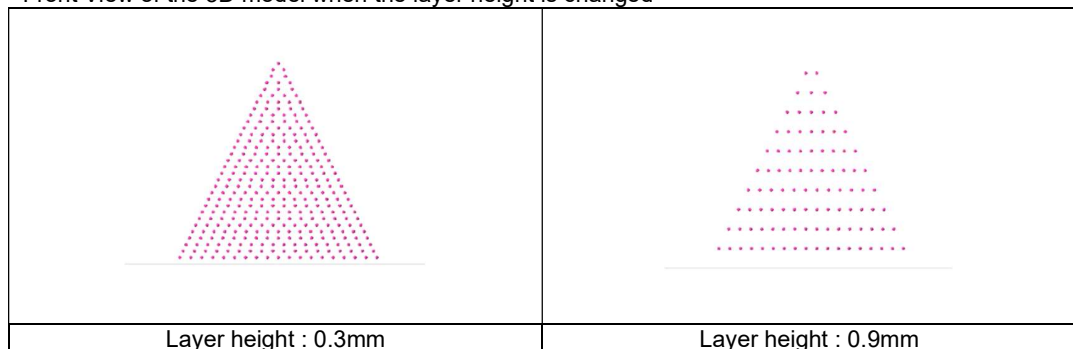
c. Slicing Setup

Allows the user to set the Layer height and Spatial Resolution of the sliced 3D model.

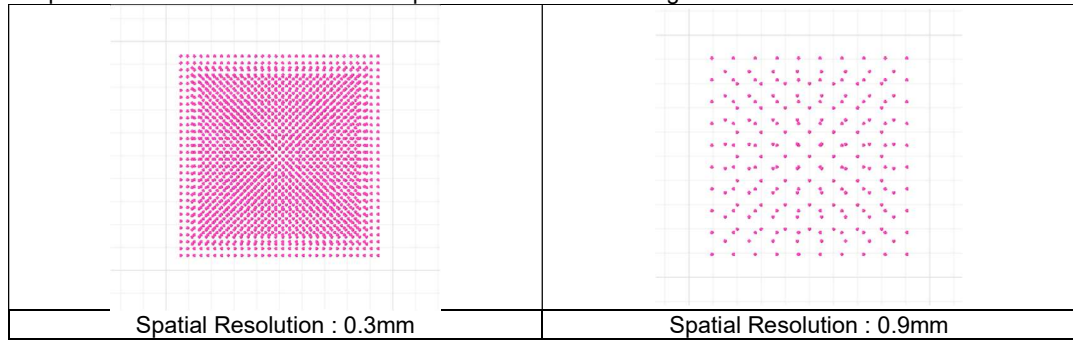
- Layer height : The distance between each layer when the 3D model is sliced. When the 3D model is sliced, the printed object's thickness is jointly determined by the Layer Height and dispensing parameters.
- Spatial Resolution : The distance between each point, and between each line on a 2D plane when the 3D model is sliced. When the 3D model is sliced, the printed object's density is determined by the spatial resolution and dispensing parameters.

Example) Pyramid Model

- Front View of the 3D model when the layer height is changed



- Top View of the 3D model when the Spatial Resolution is changed



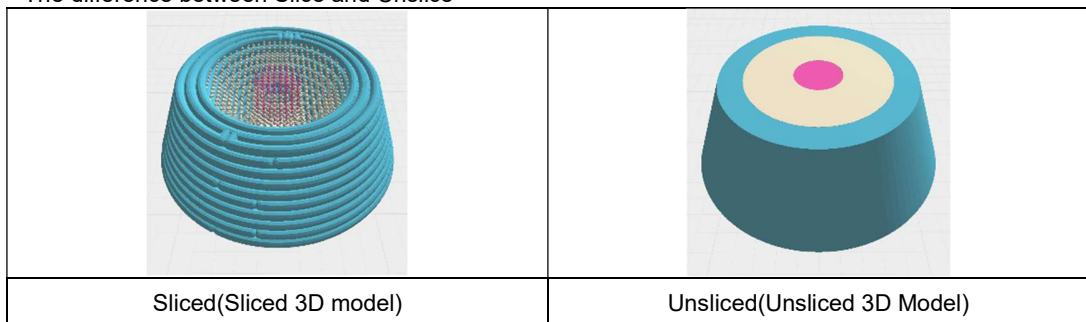
d. Display Range

The users can set the Display range of the 3D model that they wish to see through the Model Viewer.



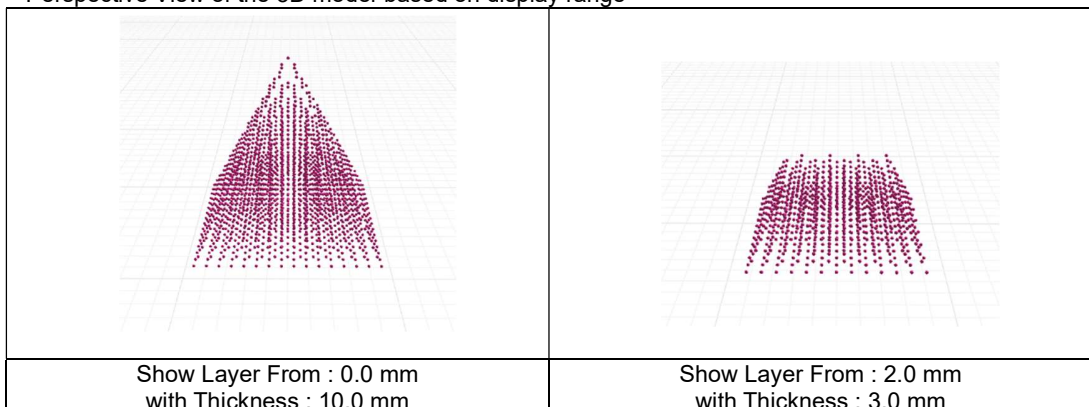
- Show Layers From : The user can set the layer height at which the 3D model is seen.
- with Thickness : The user can set the displayed thickness of the 3D model.
- Slice : When the user presses the Slice button, the 3D model is sliced per user settings.
- Unslicing : When the user presses the Unslicing button, the 3D model is reverted to its pre-slicing state.

* The difference between Slice and Unslicing



Example) Pyramid Model

- Perspective View of the 3D model-based on display range



3. Parameter Settings Tab

Name	Res.	L-Thickness	Channel
combi2_F127	0.4	0.4	Pluronic F-127
combi2_Collagen	0.4	0.3	Collagen
combi2_GelMA	0.4	0.2	GelMA

Dispensing Parameters Presets

Custom

Dispensing Parameters

Extrusion Rate: 4.0 % Load Save

Vacuum Pressure: 500 psi Restore

Distance to Surface: 0.0 mm

Temperature: N/A °C

Cross-linking Type: None

Nebulizer Channel: 0.0 sec

UV LED Channel: 1 sec

Cross-linking Parameters Presets

Custom

Cross-Linking Parameters

Power: 90 % Load Save

Duration: 3.0 sec

Distance to Surface: 30.0 mm Restore

Count: 1

Interval: 30.0 sec

Waiting Time: 30.0 sec

Next >>

The following options are displayed when pressing the 3. Parameter Settings button.

- a. Models
- b. Dispensing Parameters
- c. Cross-linking Parameters

When everything is set, the user can press the Next button to enter 4. Printing

- Load : Load a set of previously saved printing parameters.
- Save : Save the parameters as a Preset
- Restore : Load the default parameter values.

a. Models

Displays the channels that were designated to the models in the Modeling Tab, alongside the 3D model slicing parameters. When the user selects a model from the model list, the user can then change the Dispensing Parameters and Cross-linking Parameters. The user can either use the user-made presets for the Dispensing Parameters and Cross-linking Parameters, or readjust the parameters if necessary.

Name	Res.	L-Thickness	Channel
------	------	-------------	---------

- Name : Displays the name of the added model.
- Resolution : Displays the Spatial Resolution set from the Slicing Setup from the Modeling Tab.
- Layer-Thickness : Displays the Layer-Thickness set from the Slicing Setup from the Modeling Tab.
- Channel : Displays the Channel that is designated to the 3D model.

b. Dispensing Parameters

Allows the user to set the parameters regarding dispensing.

Dispensing Parameters Presets

Custom

Dispensing Parameters

Pneumatic Pressure 5.0 psi Load

Valve Opening Time 500 usec Save

Distance to Surface 0.0 mm Restore

Temperature N/A °C

Cross-linking Type Nebulizer

Nebulizer Channel 1

- Pneumatic Pressure: Allows the user to set the amount of pneumatic pressure within the valve.
- Valve Opening Time: Function that allows the user to set the amount of time the valve is open. While the valve is open, the material is printed.
- Distance to Surface: The user can set the height at where printing begins.
- Temperature: The user can set each channel's temperature. If the user has already set the temperature in the 'preparing' tab, they can select N/A. If the temperature must be calibrated, they can select a new temperature.
- Cross-linking Type: The user can select the Cross-linking method.

1) UV-LED(per Droplet)

: When one droplet is dispensed, UV-LEDs (located below the channel) irradiate the droplet. The user can change the duration of UV-LED irradiation from 'UV Irradiation Time'.

2) UV-LED(per Layer)

: When a single layer is fully printed, the UV-LED then irradiates the entire layer. The user can change the duration of UV-LED irradiation from 'UV Irradiation Time'.

3) Nebulizer

: The Nebulizer settings menu will be displayed (See c. Cross-linking Parameter)

4) UV-Lamp

: The user can change how long the UV-Lamp(Omniculture)is turned on.

c. Cross-linking Parameters

Displayed when the user selects the Nebulizer as the Cross-linking Type from the Dispensing Parameters. It sets the operating parameters of the Nebulizer.

Cross-linking Parameters Presets

Custom

Cross-Linking Parameters

Power 100 % Load

Duration 3.0 sec Save

Distance to Surface 30.0 mm Restore

Count 1

Interval 30.0 sec

Waiting Time 30.0 sec

Next >>

- Power: The user can choose the amount of nebulizing power as a percentage.
- Duration: The user can choose the duration of nebulization.
- Distance to Surface: The user can choose the height from the bioware at where the Nebulizer works.
- Count: The user can choose how many times the Nebulizer dispenses the crosslinking material.
- Interval: The user can choose the interval at which the Nebulizer dispenses, if the Nebulizer is continuously dispensing.
- Waiting Time: The user can choose the waiting period after nebulization and before printing so that proper crosslinking will be ensured. (i.e. crosslinking time may vary depending on the type and concentration of specific material),

4. Printing Tab

When the user presses the 4. Printing button, a menu that allows the user to execute Printing with the parameters set through 1. Preparing, 2. Modeling, 3. Parameter Settings pops up.

- a. Monitoring Camera
- b. Progress
- c. Additional Printing Options
- d. Report

When everything is set, the user can press the Next button to enter 5. Finalizing.

a. Monitoring Camera

The Monitoring Camera takes video/pictures of the printing process in real-time. The user can archive the printing process as a video or image file.

- Automatic video recording while printing: When selected, the Monitoring Camera automatically films the printing process when it starts. (saves as .mp4)
- Start Recording: When selected, manually begins filming the printing process. (saves as .mp4)
- Save Image: When selected, a screenshot is saved (as .png)
- Video File: When the user presses the '...' button, they can choose the directory to save the video/image files.

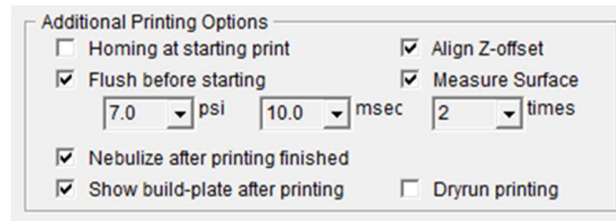
b. Printing Status

Displays information about the printing process in real-time.

- File : Displays the location of the file that is being printed.
- Progress : Displays the completion of the printing process as a Bar graph.
- Layer : Displays the current number of material layers.
- Current Job : If the printing process has not finished, Current Job displays as 'Printing'. If it is finished, it displays as 'Finished'.
- Start Time : Displays the time when the printing process began.
- Finish Time : Displays the time when the printing process will finish.
- Elapsed Time : Displays the amount of time left before the printing process concludes.
- Print / Pause : When the user presses the Print button, the printing process begins, and the Print button changes to the Pause button. When the user presses the Pause button, the printing process can be temporarily stopped.
- Resume : Appears when the Pause button is pressed. When clicked, it resumes the printing process.
- Cancel : Appears when the Pause button is pressed. When clicked, it terminates the printing process.

c. Additional Printing Options

Allows the user to select additional features for printing.

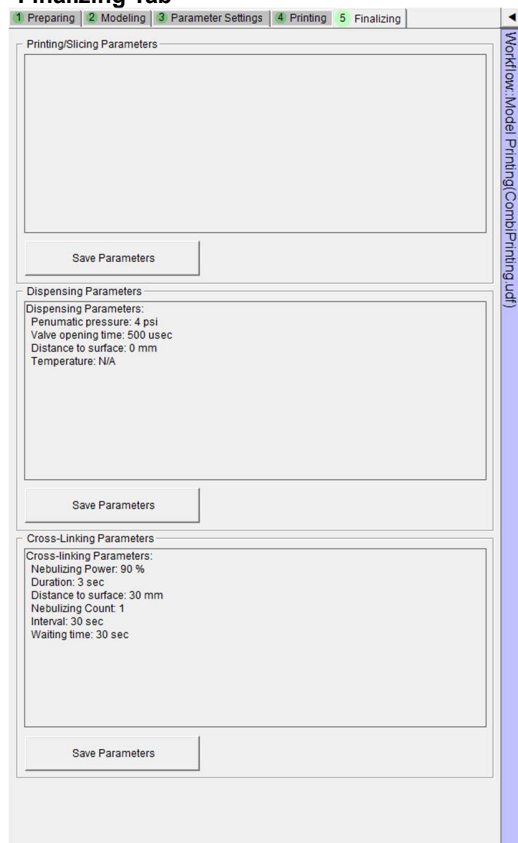


Additional Printing Options

<input type="checkbox"/> Homing at starting print	<input checked="" type="checkbox"/> Align Z-offset
<input checked="" type="checkbox"/> Flush before starting	<input checked="" type="checkbox"/> Measure Surface
<input type="text" value="7.0"/> psi	<input type="text" value="10.0"/> msec
<input checked="" type="checkbox"/> Nebulize after printing finished	<input type="text" value="2"/> times
<input checked="" type="checkbox"/> Show build-plate after printing	<input type="checkbox"/> Dryrun printing

- Homing at starting print: When selected, the build-plate moves to the Initial reference position of the U-FAB before the printing process begins.
- Align Z-offset: When selected, the build plate undergoes processes that adjust the vertical offset from the nozzle.
- Measure Surface: When selected, the distance between the buildplate and the nozzle is measured.
- Flush before starting: When selected, the channels are flushed before the printing process begins.
- Nebulize after printing finished:
- Show buile-plate after printing: When selected, the build-plate moves to the front panel of the U-FAB after the printing process finishes. When unselected, the build-plate stops at the location where the printing process finished.
- Dryrun printing: When selected, the users can simulate the entire printing process without dispensing any materials.

5. Finalizing Tab



Workflow: Model Printing(Combiprinting.pdf)

Printing/Slicing Parameters

Save Parameters

Dispensing Parameters

Dispensing Parameters:
Pneumatic pressure: 4 psi
Valve opening time: 500 usec
Distance to surface: 0 mm
Temperature: N/A

Save Parameters

Cross-Linking Parameters

Cross-linking Parameters:
Nebulizing Power: 90 %
Duration: 3 sec
Distance to surface: 30 mm
Nebulizing Count: 1
Interval: 30 sec
Waiting time: 30 sec

Save Parameters

When the user presses the 5. Finalizing button, the parameters set during Model-based printing are displayed. The user can verify and save these parameters from the Finalizing Tab

- a. **Printing/Slicing Parameters**
- b. **Dispensing Parameters**
- c. **Cross-Linking Parameters**

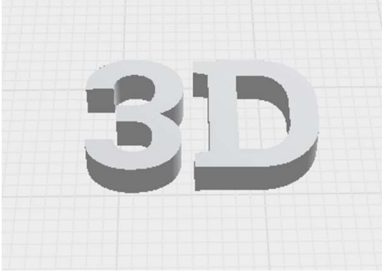
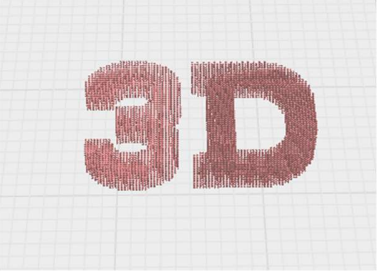
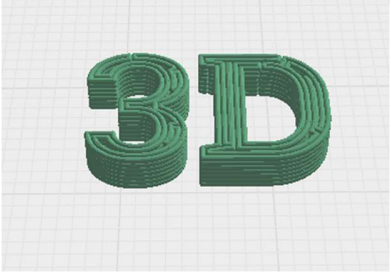
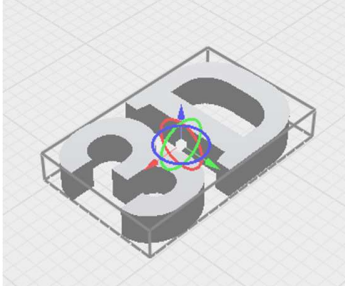
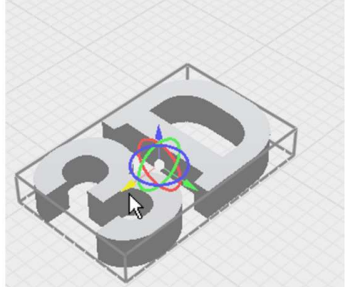
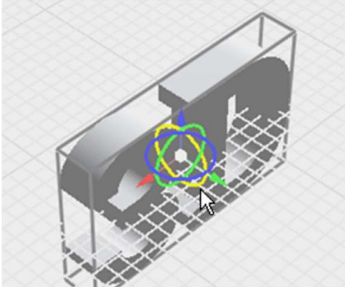
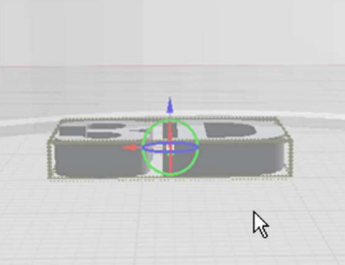
- Save Parameters: If the user presses the Save Parameters button, the parameters displayed under the Finalizing Tab are saved.

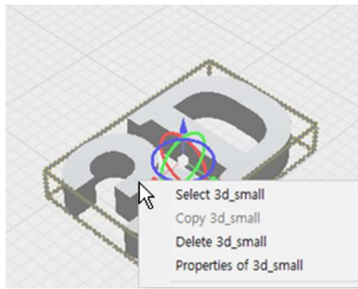
- a. **Printing/Slicing Parameters**
The user can verify and save the Printing/Slicing Parameters.
- b. **Dispensing Parameters**
The user can verify and save the Dispensing Parameters.
- c. **Cross-Linking Parameters**
The user can verify and save the Cross-Linking Parameters

D. Model Viewer

The Model Viewer, being displayed at the right side of the Main Window, reflects the parameters set by the user in each menu onto the 3D model in real-time.

Slice View is displayed differently depending on the channel type(Droplet / Extrusion). When the user clicks on the Model displayed in the Model Viewer, icons that allow the user to rotate/move the Model appear in the middle of the Model.

		
Model View	Slice View(Droplet)	Slice View(Extrusion)
	<p>[Model Control Icon] When the user selects the 3D model, the icon on the left appears in the middle of the model. The user can use this to rotate or move the model.</p>	
	<p>[Drag the arrows after left clicking] The user can move the model when they drag the 3 arrows. (The selected arrow is displayed as yellow.)</p>	
	<p>[Drag the circles after left clicking] The user can rotate the model when they drag the model clockwise/counterclockwise after clicking on the circular rings(blue, green, red). (The selected circular ring is displayed as yellow)</p>	
	<p>[Drag the background after left clicking] The user can change the point of view at which they view the model when they drag the 3D model's background.</p>	



[Right Click the Model]

When the user right clicks a model, a drop down menu is displayed that gives access to the following functions.

- Select <Model Name> : When selected, the 3D model becomes selected.
- Copy <Model Name> : When selected, the 3D model is copied.
- Delete <Model Name> : When selected, the 3D model is deleted.
- Properties <Model Name> : When selected, displays the properties of the 3D model.

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E. Version history

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