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Biofabrication

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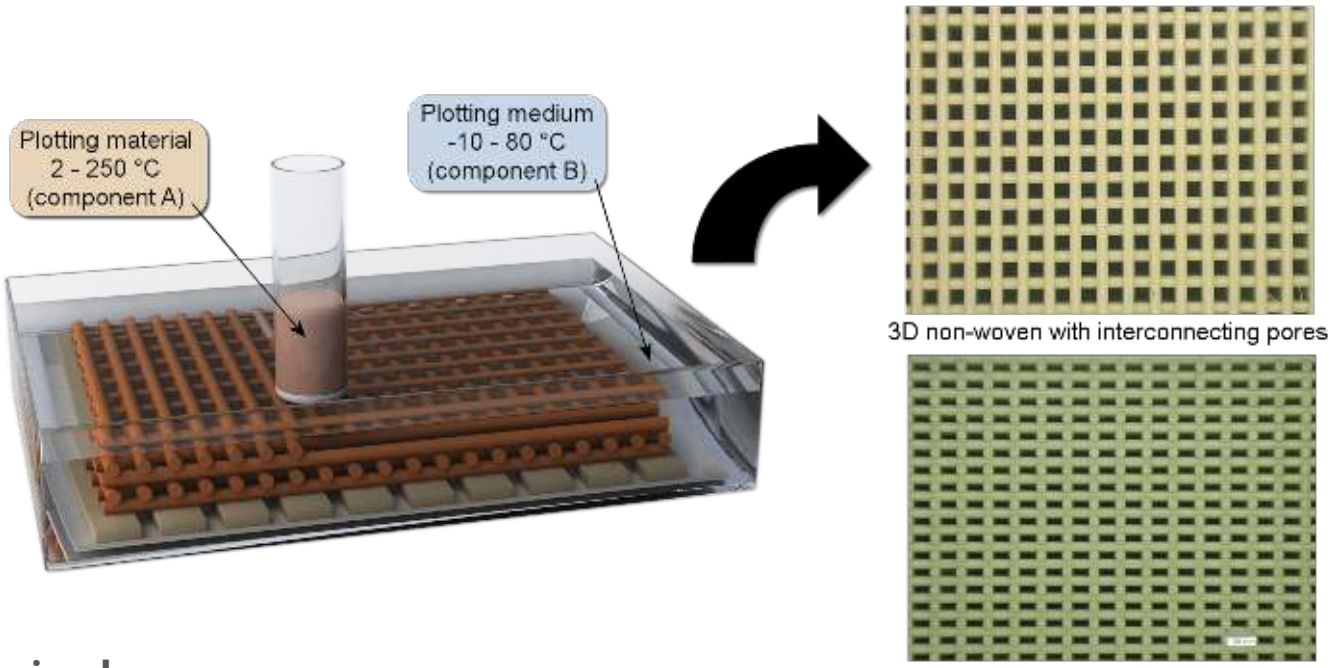
The 3D-BIOPLOTTER® Process



A simple process:

A liquid, melt, paste or gel is dispensed from a material cartridge through a needle tip from a 3-axis system to create a 3D object.

One single requirement:

The material to be used must, through a physical or chemical reaction, solidify.

A world of possibilities:

The widest range of materials of any 3D printing technology can be processed.

Key Features 3D-BIOPLOTTER®

Vibration-free robust machine frame designed for durability and stability during continuous use

Multi-part and multi-material capable through the use of an automatic tool changer and multiple print heads

Modular head design allows users to add new features to existing machines (MANUFACTURER and DEVELOPER only)

Needle tip cleaning station, with automatic cleaning before and during the print project available

Luer Lock needle tips, 0.1mm to 1.2mm inner diameter available

Medical grade as well as cell-laden materials can be used.
Uses raw materials (powders, pellets, etc.) without requiring a preprocessed filament

Not locked to any proprietary materials. Customers can choose their preferred vendors, as well as required medical grades, mixture compositions and concentrations, additives, etc.

Hardware

Individual temperature control of each printing head, both in the parking positions, as well as during printing

Designed for use in a sterile environment within a biosafety cabinet. 3D-Bioplotter include built-in particle and sterile filters for the input compressed air

Materials are kept in sterilizable cartridges, thus avoiding touching the machine. This makes the 3D-Bioplotter easier to clean and sterilize

Automatic substrate height detection for petri dishes, well plates, as well as other printing surfaces (DEVELOPER and MANUFACTURER only)

Automatic recalibration of critical hardware settings in the background during regular use

Remote Support included to ensure fastest possible response anywhere in the world

Footprint (L x W x H): 976 x 623 x 773 mm (38.4" x 24.5" x 30.4")
Weight: 90-130 kg (depending on the model)
Electrical Requirements: 100-240 V AC, 50/60 Hz
Compressed Air Requirements: 6 - 10 bar (85 - 145 psi)

Key Features 3D-BIOPLOTTER®

Complete control of all printing parameters (temperature, pressure, speed, etc.) through the software

Database of materials, user-editable, with all process parameters (temperature, pressure, speed, etc.)

A User Management System allows individual users to both share projects, materials and patterns, as well as have their own separate set of settings for improved overview and security

Database of inner patterns (user-editable) in the controlling software, avoiding requiring the design of patterns in the STL files

Complex inner patterns with straight lines, zig-zag shapes and wave forms, as well as hexagon shapes, including shift functions for “in between the lines” printing (hybrid scaffolds)

Input of outer shapes through STL or 3MF files independent of the source (CAD software, CT scanner, etc.)

Software

Log file creation after project completion with all relevant data

Simple automatized generation of volume supports for complex shapes

Material life time control to avoid scaffold fabrication with degraded materials

Improved surface finish of fabricated parts using randomized start positions in outer contours

Multiple contour control for reinforcement of outer structures

Temperature curves with up to 5 set points and waiting times (DEVELOPER and MANUFACTURER only)

Built-in high definition camera for high accuracy calibration, print parameter tuning and mid-print measurement of strand dimensions (MANUFACTURER only)

Photographic log of the full object for each layer available for verification of error-free object interior after printing (MANUFACTURER only)

4th Generation 3D-BIOPLOTTER®
MANUFACTURER SERIES

- Designed both as a tool for advanced Tissue Engineering research, as well as for use in a production environment.
- Capable of using all hardware and software options of the 3D-Bioplotter Series.
- Includes heated platform and sterile filter, recommended for Cell Printing / Organ Printing.

Machine Specification
Manufacturer Series

Axis Resolution (XYZ)	0.001 mm (0.00004″)
Speed	0.1 - 150 mm/s (0.004″ - 5.91″/s)
Pressure	0.1 - 9.0 bar (1.45 - 130 psi)
Build Volume (XYZ)	200 x 220 x 140 mm (7.87″ x 8.66″ x 5.51″)
Needle Position Control	Z-Sensor + High Resolution Camera
Camera Resolution (XY)	0.009 mm (0.00035″) per Pixel
Needle Sensor Resolution (Z)	0.001 mm (0.00004″)
Minimum Strand Diameter	0.100 mm (0.004″) - Material Dependent
Number of Materials per Scaffold	Maximum 5 Materials Using 5 Print Heads
Print Heads Included	1x Low and 1x High Temperature Head
Filters Included	Particle and Sterile Filters
Platform Temperature Control	Heating and Cooling Capable (-10°C to 80°C)
Platform Height Control	Automatic Z-height Controlling System
Material Calibration	Semi-Automatic Material Calibration
Additional Features	Automated Nozzle Cleaning Process
	4 External Temperature Sensor Ports
	Layer by Layer Photographic Log

4th Generation 3D-BIOPLOTTER®
DEVELOPER SERIES

- Designed for research groups new to the field of Tissue Engineering, as well as for specialized use, where the limited capability still meet requirements.
- Consisting of the same basic hardware and software as the Manufacturer Series, but with reduced functionality regarding camera and park positions.
- Not upgradable to the same capability of the Manufacturer Series.

Machine Specification
Developer Series

Axis Resolution (XYZ)	0.001 mm (0.00004″)
Speed	0.1 - 150 mm/s (0.004″ - 5.91″/s)
Pressure	0.1 - 9.0 bar (1.45 - 130 psi)
Build Volume (XYZ)	200 x 220 x 140 mm (7.87″ x 8.66″ x 5.51″)
Needle Position Control	Photo Sensor
Camera Resolution (XY)	-
Needle Sensor Resolution (XYZ)	0.03 mm (0.0012″)
Minimum Strand Diameter	0.100 mm (0.004″) - Material Dependent
Number of Materials per Scaffold	Maximum 3 Materials using 3 Print Heads
Print Heads Included	1x Low and 1x High Temperature Head
Filters Included	Particle and Sterile Filters
Platform Temperature Control	Heating and Cooling Capable (Chiller not included)
Platform Height Control	Automatic Z-height Controlling System
Material Calibration	Manual Material Calibration
Additional Features	Automated Nozzle Cleaning Process
	-
	-

4th Generation 3D-BIOPLOTTER®
STARTER SERIES

- Designed for research groups new to 3D Printing & Tissue Engineering with few requirements in parallel material processing and automation.
- Consisting of the same basic hardware and software as the Manufacturer & Developer Series, but lacking modular capability and platform temperature control.
- Not upgradable to the same capability of the Developer or Manufacturer Series.

Machine Specification
Starter Series

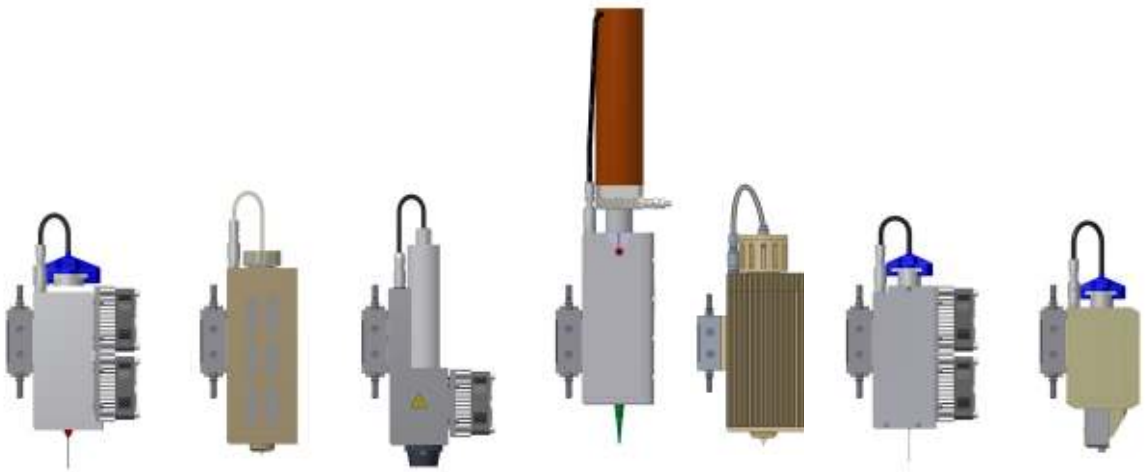
Axis Resolution (XYZ)	0.001 mm (0.00004″)
Speed	0.1 - 150 mm/s (0.004″ - 5.91″/s)
Pressure	0.1 - 9.0 bar (1.45 - 130 psi)
Build Volume (XYZ)	260 x 220 x 70 mm (10.24″ x 8.66″ x 3.15″)
Needle Position Control	Photo Sensor
Camera Resolution (XY)	-
Needle Sensor Resolution (XYZ)	0.03 mm (0.0012″)
Minimum Strand Diameter	0.100 mm (0.004″) - Material Dependent
Number of Materials per Scaffold	Maximum 2 Materials
Print Heads Included	2x Fixed High Temperature Heads (incl. adapter for smaller cartriges)
Filters Included	Particle Filter
Platform Temperature Control	Upgradeable
Platform Height Control	Manual
Material Calibration	Manual Material Calibration
Additional Features	Automated Nozzle Cleaning Process
	-

3D-BIOPLOTTER® at a glance

MANUFACTURER SERIES	DEVELOPER SERIES	STARTER SERIES
Footprint: 976 x 623 x 773 mm (38.4 x 24.5 x 30.4 in)	Footprint: 976 x 623 x 773 mm (38.4 x 24.5 x 30.4 in)	Footprint: 850 x 623 x 773 mm (33.5 x 24.5 x 30.4 in)
Max Build Area: 200 x 220 x 140 mm (7.87" x 8.66" x 5.51" in)	Max Build Area: 200 x 220 x 140 mm (7.87" x 8.66" 5.51" in)	Max Build Area: 260 x 220 x 70 mm (10.24" x 8.66" x 3.15" in)
5 max modular heads, 2 included	3 max modular heads, 2 included	2 Fixed High Temp Heads included
Needle Tip Calibration (XY): 9 µm	Needle Tip Calibration (XY): 30 µm	Needle Tip Calibration (XY): 30 µm
Needle Tip Calibration (Z): 1 µm	Needle Tip Calibration (Z): 30 µm	Needle Tip Calibration (Z): 30 µm
Particle and Sterile Filters	Particle and Sterile Filters	Particle Filter only
Industrial PC with automatic hard drive backup system	Industrial PC with automatic hard drive backup system	All-in-One PC, manual backup ready
Heated and Cooled Platform -10 °C to 80 °C	Optional Heated and Cooled Platform -10 °C to 80 °C	Upgradeable to Heated and Cooled Platform -10°C to 80°C
Temperature Curves, 5 points	Temperature Curves, 5 points	-
Substrate Height Sensor	Substrate Height Sensor	-
Semi-Automatic camera assisted material calibration	-	-
Photographic log during printing	-	-

Modular Heads

Head type	Temperature range	Cartridge size
Low Temperature Dispensing Head	0 - 70°C	30 ml
High Temperature Dispensing Head	30 - 250°C	10 ml
Ultra-High Temperature Dispensing Head	30 - 500°C	12 ml
2-Component Dispensing Head	25 - 70°C	50 ml
Co-Axial Low Temperature Dispensing Head	0 - 70°C	2 x 10 ml
Ink Jet Dispensing Head	25 - 70°C	10 ml
Photo-Curing Head	5 wavelength combination, user adjustable 365, 385, 395, 405, 445 nm	



Accessories and Upgrades

Biosafety Cabinet

Class II, Type A2
Outer: 167 x 97 x 249 – 264 cm
(65 5/8 x 38 1/8 x 98 - 104 “)
Inner: 148 x 73 x 92 cm
(58 3/8 x 28 3/4 x 36 1/2“)

Compressor

Max Pressure: 7 bar (100 PSI)
Oil-free, built-in 5 L tank
Silent, max 56 dBA
23 x 44 x 39 cm, 20 kg
110 / 230 V variants available

Pressure Booster

Doubles input pressure
Max Pressure: 10 bar (150 PSI)
Built-in 3 L tank
37 x 34 x 36 cm, 10 kg
No electricity required

Consumables

Needle tips 0.1 mm – 1.2 mm
Cartridges 3 ml – 30 ml
Printing Substrates
Flat Petri Dishes

READY TO PRINT MATERIALS

Bone/Cartilage materials

Product Name	Material	Grade
LT Hydroxyapatite RG	Hydroxyapatite, self-settling	Research
HT PCL 45K RG	Polycaprolactone, MW 45 kDA	Research
HT PCL 80K MG	Polycaprolactone, MW 80 kDA	Medical
HT PCL 120K MG	Polycaprolactone, MW 120 kDA	Medical

Soft Tissue materials

Product Name	Material	Grade
UV Silicone 60A MG	Silicone, short term only, 365nm	Medical
LT TissueInk RG	Gelatin-based hydrogel mixture for cell printing	Research
2K Silicone 50A RG	Silicone, 2 component, heat post-cured	Research

Support materials / others

Product Name	Material	Grade
HT Support RG	Sugar-based	Research
LT Support RG	Cellulose-based	Research
LT Silicone TG	Silicone, RTV1	Technical

All materials are delivered with processing parameters and instructions of use.

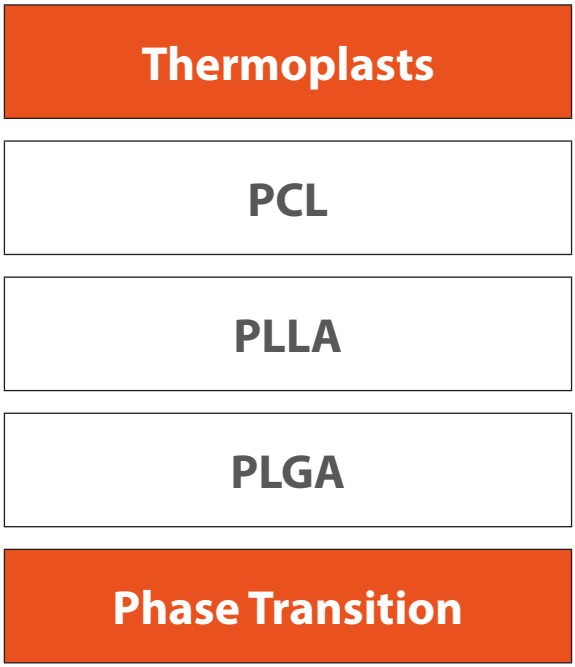
Application: Bone Regeneration

Ceramic/Metal Pastes	Thermoplasts
Hydroxyapatite	PCL
Titanium	PLLA
Tricalcium Phosphate	PLGA
Sintering	Phase Transition

Sample Papers:

- Zidan, Ahmed, et al. **„Extrudability analysis of drug loaded pastes for 3D printing of modified release tablets.“** International journal of pharmaceutics 554 (2019): 292-301.
- Haberstroh, K., et al. **„Bone repair by cell-seeded 3D-bioplotted composite scaffolds made of collagen treated tricalciumphosphate or tricalciumphosphate-chitosan-collagen hydrogel or PLGA in ovine critical-sized calvarial defects.“** Journal of Biomedical Materials Research Part B: Applied Biomaterials 93.2 (2010): 520-530.
- Jakus A.E., et al. **„Hyperelastic “bone”: A highly versatile, growth factor–free, osteoregenerative, scalable, and surgically friendly biomaterial.“** Science translational medicine. 28.8 (2016): 358ra127.
- Sapkal P.S., et al. “**3D Bio-Plotted Tricalcium Phosphate/Zirconia Composite Scaffolds to Heal Large Size Bone Defects.**” Molecular & Cellular Biomechanics 14.2 (2017): 125-136.

Application: Drug Release



Sample Papers:

- Kammerer, M., et al. „**Valproate release from polycaprolactone implants prepared by 3D- bioplotting.**“ Die Pharmazie-An International Journal of Pharmaceutical Sciences 66.7 (2011): 511-516.
- Yilgor, P., et al. „**An in vivo study on the effect of scaffold geometry and growth factor release on the healing of bone defects.**“ Journal of tissue engineering and regenerative medicine 7.9 (2013): 687-696.
- Siyawamwaya M., et al. „**3D printed, controlled release, tritherapeutic tablet matrix for advanced anti-HIV-1 drug delivery.**“ European Journal of Pharmaceutics and Biopharmaceutics. (2018)
- Zhu, M., et al. „**3D-printed hierarchical scaffold for localized isoniazid/rifampin drug delivery and osteoarticular tuberculosis therapy**“. Acta Biomaterialia, 16 (2015): 145-155.
- Zhang, J., et al. „**3D-printed magnetic Fe3O4/MBG/PCL composite scaffolds with multifunctionality of bone regeneration, local anticancer drug delivery and hyperthermia.**“ Journal of Materials Chemistry B 2.43 (2014): 7583-7595.

Application: Soft Tissue & Cartilage Fabrication Cell Printing & Organ Printing

Hydrogels			
Agar	Silk	Alginate	Chitosan
Gelatin	Hyaluronic Acid	Fibrin	Collagen
Phase Transition		2 Component System	Precipation

Sample Papers:

- Billiet, T., et al. „**The 3D printing of gelatin methacrylamide cell-laden tissue-engineered constructs with high cell viability.**“ Biomaterials 35.1 (2014): 49-62.
- Cengiz I.F., et al. „**Building the basis for patient-specific meniscal scaffolds: from human knee MRI to fabrication of 3D printed scaffolds.**“ Bioprinting 1 (2016): 1-10.
- Laronda M.M., et al. “**A bioprosthetic ovary created using 3D printed microporous scaffolds restores ovarian function in sterilized mice.**” Nature Communications 16.8 (2017): 15261.
- Huang L, Du X, Fan S, Yang G, Shao H, Li D, Cao C, Zhu Y, Zhu M, Zhang Y. **“Bacterial cellulose nanofibers promote stress and fidelity of 3D-printed silk based hydrogel scaffold with hierarchical pores.”** Carbohydrate polymers. 2019 May 30.
- Izadifar, Z., et al. “**Analyzing biological performance of 3D-printed, cell-impregnated hybrid constructs for cartilage tissue engineering.**”Tissue Engineering Part C: Methods. 22.3 (2016): 173-188.
- Ning, Liqun, et al. **“Characterization of cell damage and proliferative ability during and after bioprinting.”** ACS Biomaterials Science & Engineering 4.11 (2018): 3906-3918.

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4D Printing and Other Applications

Other Materials			
Polyurethane	Silicone	Acrylates	Graphene
Phase Transition	RTV 1	UV Curing	Evaporation

Sample Papers:

- Kiziltay, A., et al. „**Poly (ester-urethane) scaffolds: effect of structure on properties and osteogenic activity of stem cells.**“ Journal of tissue engineering and regenerative medicine 9.8 (2015): 930-942.
- Bakarich, S. E., et al. „**4D printing with mechanically robust, thermally actuating hydrogels.**“ Macromolecular rapid communications 36.12 (2015): 1211-1217.
- Nathan-Walleser, T., et al. „**3D Micro-Extrusion of Graphene-based Active Electrodes: Towards High-Rate AC Line Filtering Performance Electrochemical Capacitors.**“ Advanced Functional Materials 24.29 (2014): 4706-4716.
- Jakus, A. E., et al. “**Three-dimensional printing of high-content graphene scaffolds for electronic and biomedical applications.**” ACS nano 9.4 (2015): 4636-4648.

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http://envisiontec.com/3d-bioplotter-research-papers/

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