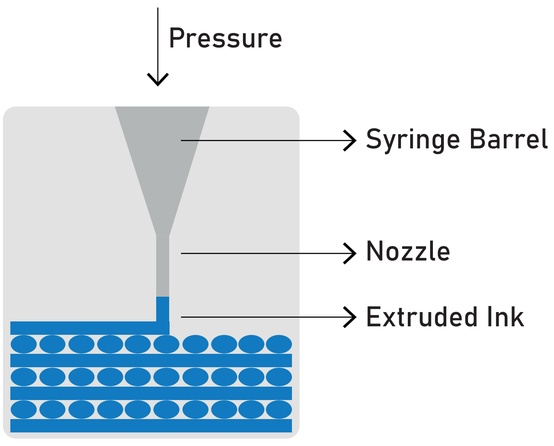
LVIII SECV National Congress

Direct Ink Writing: multi-purpose capability to develop equipment for Ceramics AM research

Direct Ink Writing (DIW)

Direct Ink Writing (DIW) is an extrusion-based 3D printing technique in which materials are deposited in a layerwise method, by continuous rising of the print head, in order to create a 3D structure. The material is processed as ink and its viscosity is one of the relevant linked parameters. The capacity of retaining a shape upon deposition is very important for the AM process.



Nozzle diameters

Caliber	Diameter (mm)
14	1.60
16	1.19
18	0.84
20	0.58
22	0.41
25	0.25

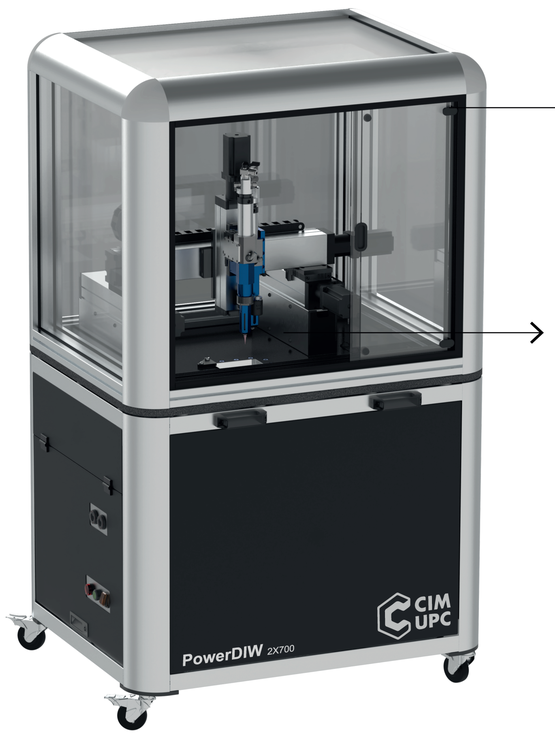
Workflow

From de CAD file, DIW technology will be used for most of the particles to obtain a funtional part after a post-processing. Depending on the application or material, is not always necessary to post-process the part.

Digital File → DIW Process → Green Part → Post Processing → Functional part

- Digital File: . STL . AMF . 3MF
- DIW Process: . Printed path . Printing Parameters
- Post Processing: . Drying . Debinding . Sintering

3D Printer



Enclosure

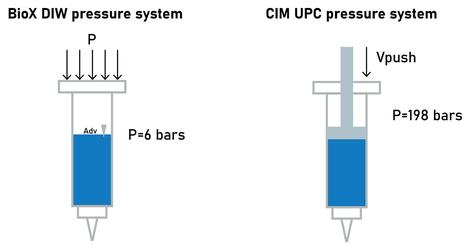
- Humidity control (25% to 98% RH)
- Temperature control (20°C-40°C)
- HEPA filter
- UVA

Printheads

- 1 or 2 DIW Printheads (4°C-40°C)
- Cartridge Sizes: 3cc - 5cc - 10cc
- Maximun Force: 850N
- FFF printhead

Main characteristics

Machine size (width x length x height)	1 m x 0.75 m x 1.75 m
Maximum speed	97mm/s
Minimum Nozzle Diameter	0.100 m
Axis Resolution (XYZ)	25 um
Maximum pressure in the syringe	3.6 Bar
Minimum printable volume	0.61 mm^3
Build Volume (XYZ)	96 x 100 x 100 mm



- Complete control of printing parameters (temperature, pressure, speed) through the software and motion.
- Multiextrusion System up to 2 DIW and 1 FFF Head
- High pressure System up to 850N
- High grade mechanics and motion

Research in DIW

Research on Additive Manufacturing (AM) products and processes and specially DIW are being boosted thanks to several reasons: accessible non-proprietary technology, wide span of applications, and novelty of most of the research lines.

Some of the tailored printing parameters at researcher's demand are such as size, speed, temperature, tightness, and sterilization, which are not within the reach of commercial DIW 3Dprinters.

This poster presents CIM UPC capabilities for a tailored DIW 3D printer, where researchers can ask for a special configuration to perform their activities. These capabilities are demonstrated, showing examples of different design parameters for different applications:

- Copper ink formulated with a solid content of copper, 35 vol%, added to a Pluronic stock solution. 0.5wt% of dispersant (Dolapix PC-75), with respect to the solid content.
- Dense yttria-stabilized zirconia (YSZ)
- Alumina (α-Al2O3) ceramic materials

Advantages

VERSATILE

- DIW technology enable users to **experiment** very easily.
- Wide range of **materials** can be used.
- **Small amount** of material is requiered to print, minimizing waste materials.

PRECISE

- High grade mechanics and motion

EASY TO USE

- Easy to **install** and to **use**.
- No need of specific softwares.

AFFORDABLE

- Affordable cost equipment compared with propietary 3D printers.

Materials

Normally, the materials in DIW technology are inks. Specific reological properties must have in order to obtain a good printability. The ink behaves as a pseudo-solid after deposition.

BIOINKS | METALS | CERAMICS | HYDROGELS | POLYMERS

Applications

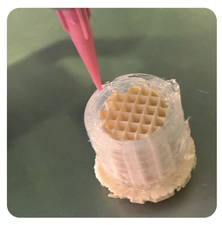
Given the number of materials that can be printed, applications are very varied. Also, different geometries can be formed from the technique.

ELECTRONICS | TISSUE ENGINEERING | BIOMEDICINE | SOFT ROBOTICS

Case Study

Recovered metal inks

During FENIX project (H2020-NMBP-2017) recovered metal powder (Ni, Cu, Sn, Fe) from **electronic waste** were mixed with hydrogels and dispersant to formulate and print specials inks.



Soft materials

Soft materials, such us silicones or hydrogels are able to be printed with DIW technology. **Silicone medical devices or 3D printed scaffolds** are one of the most well known applications.

Ceramics

DIW is the main additive manufacturing technique for ceramics because it allows versatile ink compositions, complex geometries and macroporous ceramics to be printed quickly. Examples include Hydroxyapatite, zirconia or Tricalcium Phosphate.

Conductive inks

Transport project (COMR-DI16-1-0010) aims to **embed electronics** in 3D printed geometries with the objective of integrating wire management inside a part.

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