Manufatura Aditiva na transformação digital - uma estratégia a cumprir

Martinho Oliveira

EMaRT Group – Emerging: Materials, Research, Technology

CICECO – Aveiro's Institute of Materials

Diretor - Escola Superior Aveiro-Norte

Universidade de Aveiro

Webinar "Digital Take off | Manufatura aditiva na Transformação Digital"

28 de Maio de 2020

By Microsoft Teams

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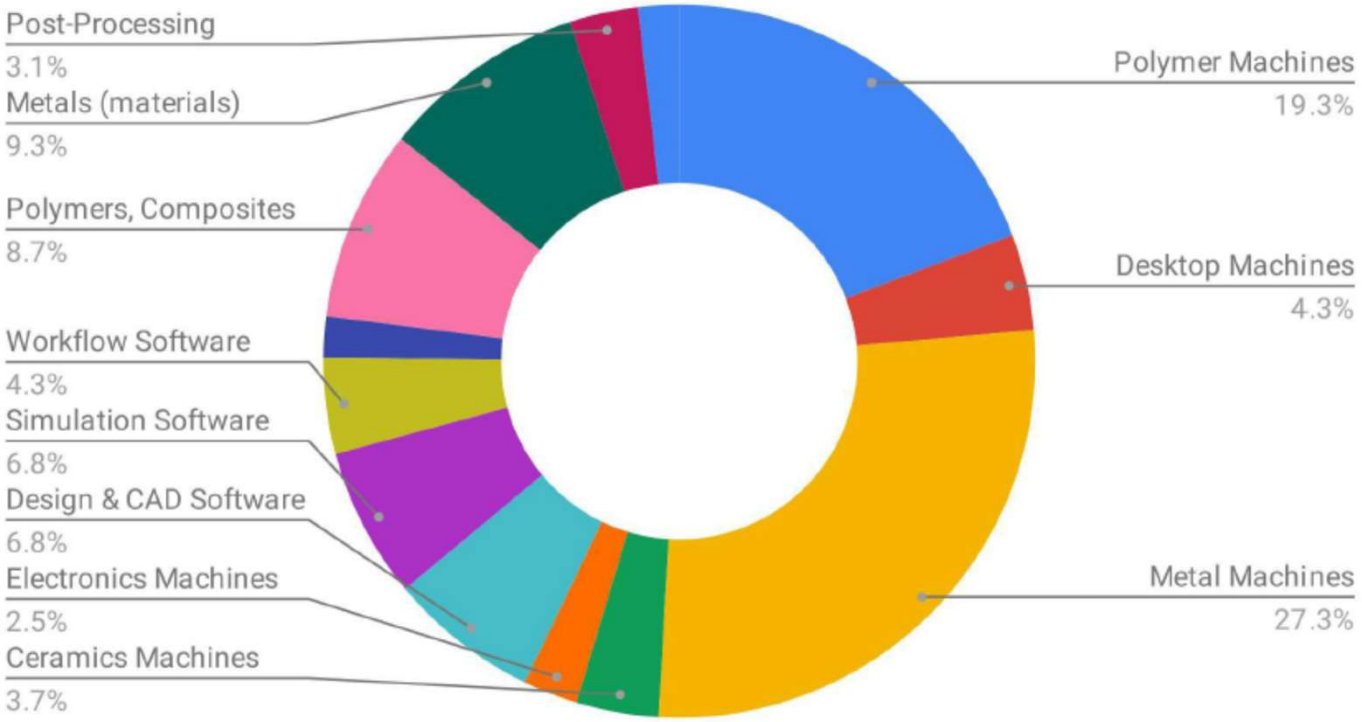
SCHOOL OF DESIGN, MANAGEMENT AND PRODUCTION TECHNOLOGIES NORTHERN AVEIRO

Technology | Product development | Materials

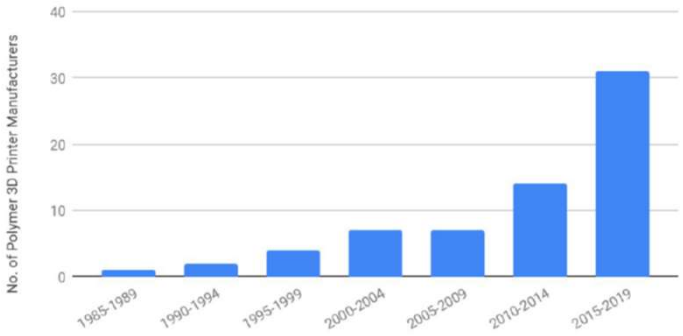
Industrial activity:
- Plastic and mould industry
- Car components
- Metalworking
- Footwear
- Cork industry
- Food products

AM landscape (hardware, software, materials, post-processing

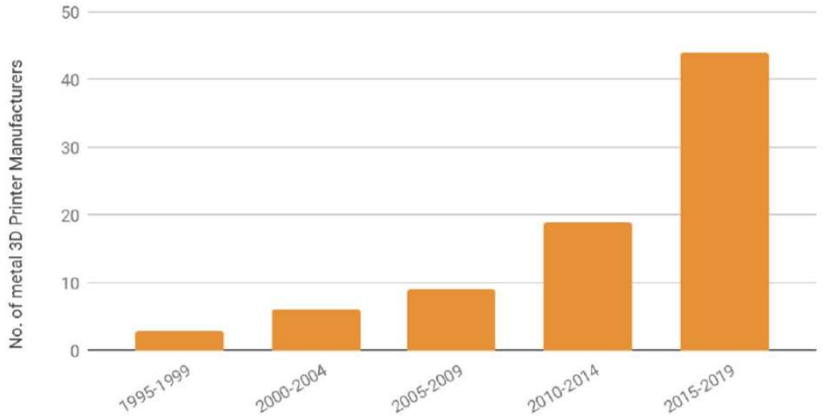


Source: AMFG, 2019

number of polymer and metal AM systems manufacturers



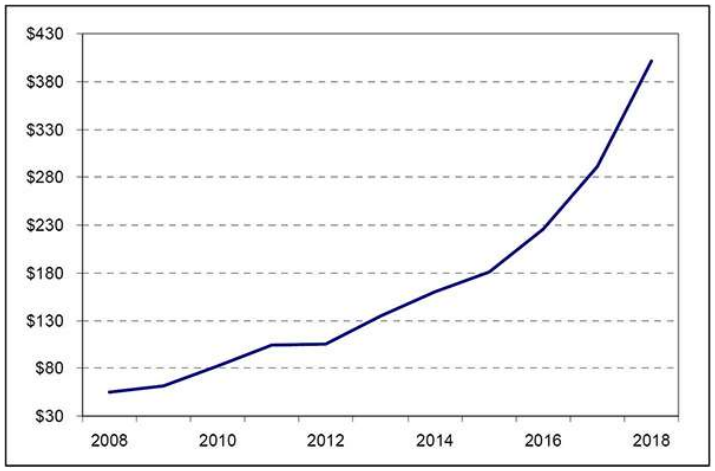
Polymer AM manufacturers



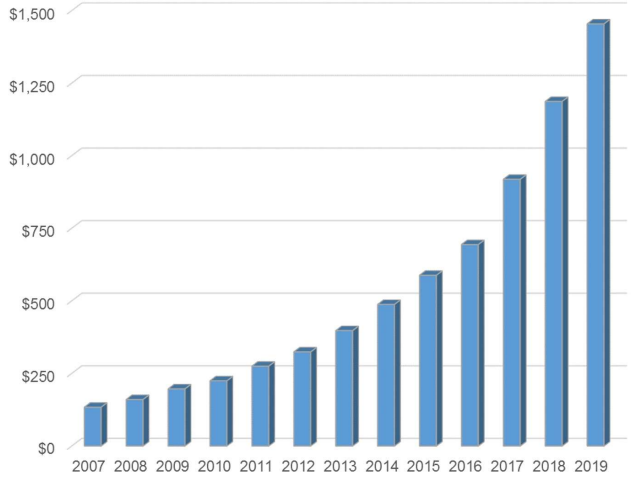
Metal AM manufacturers

Source: AMFG, 2019

Sales evolution of materials and money spent in AM production



Sales of materials for polymer powder bed fusion.
Figures are in millions of dollars.
Source: Wohlers Report 2019.



Money spent annually on part production using AM.
Figures are in millions of dollars.
Source: Wohlers Report 2020

AM: opportunities, key industries and limitations

AM is being recognized across different industries

Opportunities for AM:

- *decline of some traditional manufacturing sectors*
- *environment sustainable products an production methods*
- *innovative products and production lines/flux*
- *customization*
- *global economy centered in the individual*

3 key industries: Automotive, Aerospace, Medical

- *Automotive: new products to market quickly and in a cost effective way*
- *Aerospace: very complex and high performance products*
- *Medical: easy of converting 3D medical imaging data; customization*

AM limitations:

- *education/training*
- *speed*
- *accuracy*
- *materials properties*
- *business implications received limited attention*

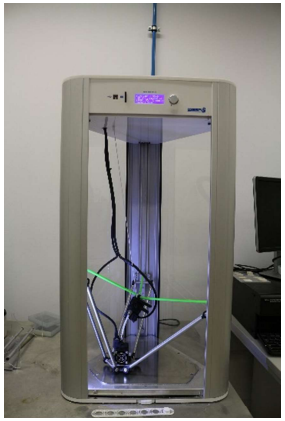
Liquid-based rapid manufacturing techniques

. Starting material is a liquid

. About a dozen rapid manufacturing technologies are in this category, examples of commercial solutions:

Stereolithography (SL)
Solid ground curing (SGC)
Polyjet
Droplet deposition manufacturing (DDM)
Robocasting or Direct Ink Writing (DIW)

Polymerization



Solid-based rapid manufacturing techniques

. Starting material is a solid

. Solid-based RP systems include the following processes:

Laminated object manufacturing (LOM)

Fused deposition modeling (FDM/FFF)

Powder-based rapid manufacturing techniques

. Starting material is a powder

. Powder-based RP systems include the following:

Selective laser sintering (SLS)

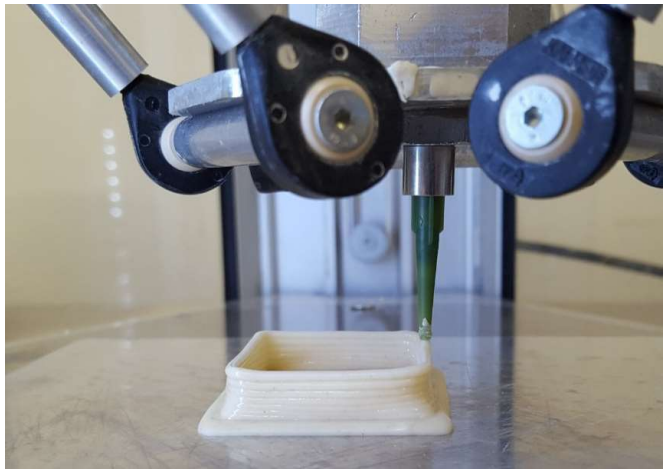
Selective laser melting (SLM)

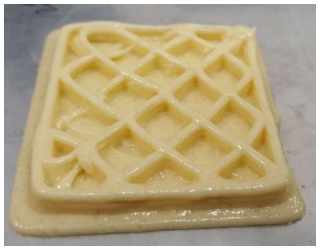
(Simoldes Aços)

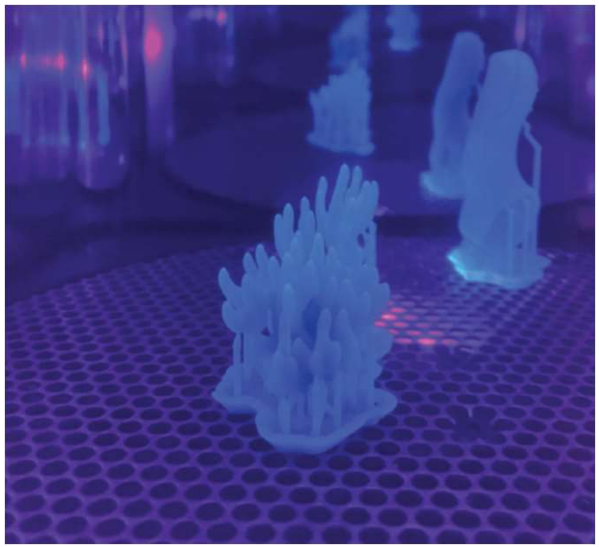
Electron Beam Melting (EBM)

Three dimensional printing (3DP)

Food and Corals by R3D: student projects







Goals:

- Introduction to AM
- Materials Science for Design Students: characterization and properties

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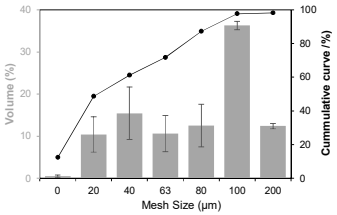
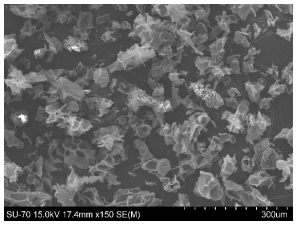
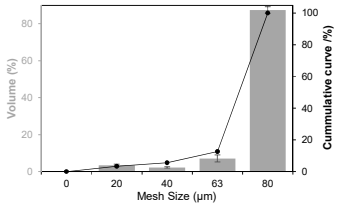
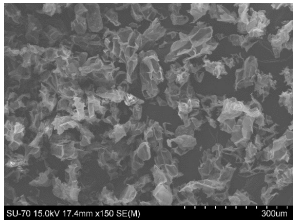
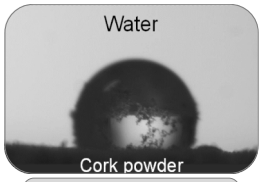
Cork by 3DP







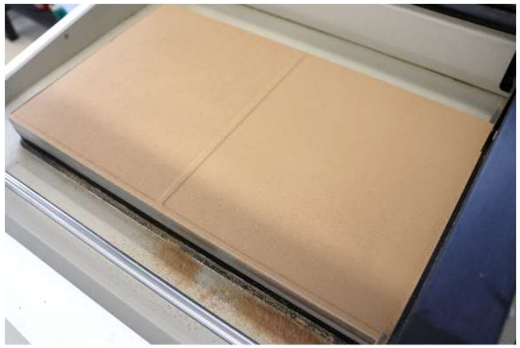




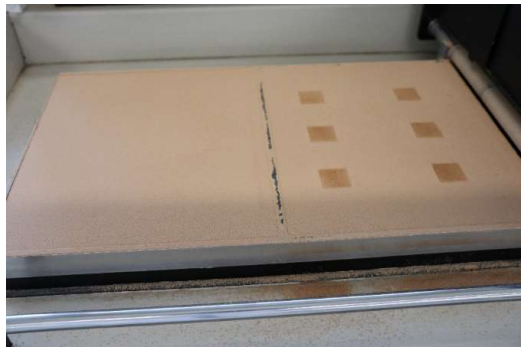
Hydrophobic behaviour
(Θ = 179°)*

Cork powder (98%v/v)
+
Additives

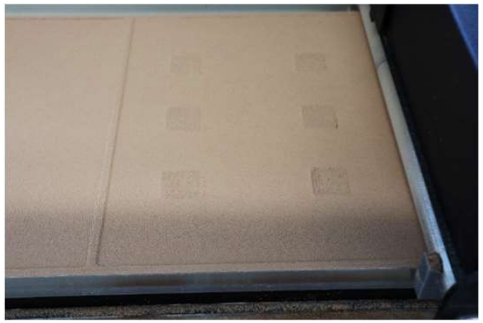
AMORIM
AMORIM CORK COMPOSITES



Homogeneous surface and dispersion



After binder deposition



After the deposition of a new layer of cork powder

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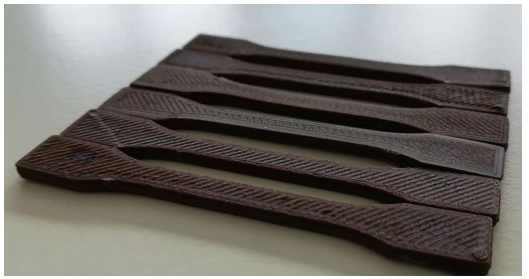
Cork by FFF

A biodegradable composite



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AMORIM CORK COMPOSITES

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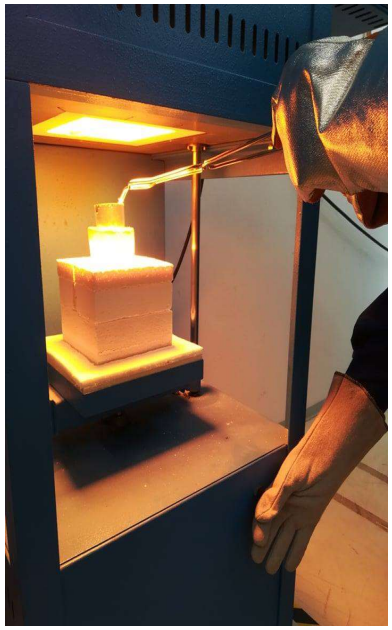
Glass by H-R3D

Goals:

- Equipment for Glass AM
- Glass formulations



ADD.VITRUM

VIDROMECANICA GLASS MACHINERY TECHNOLOGY

FAVICRI hand & blown glass

POLITÉCNICO DE LEIRIA

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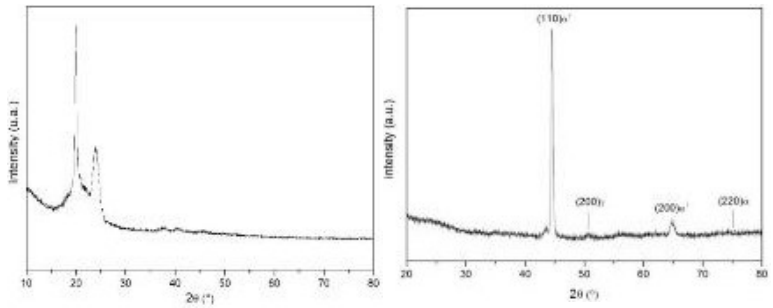
AMCUBED

BF Glass Studio

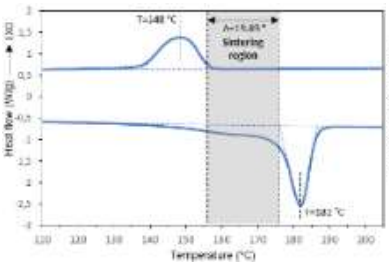
NORMAX

Metal parts for injection moulds by SLS/SLM

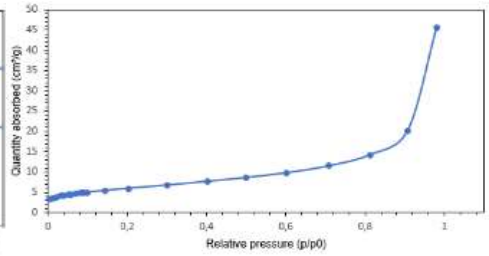
Indirect SLS and Direct SLM



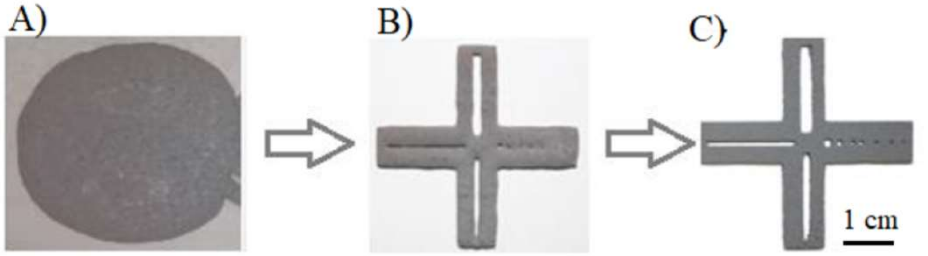
XRD of PA12 and powder maraging steel (2709)



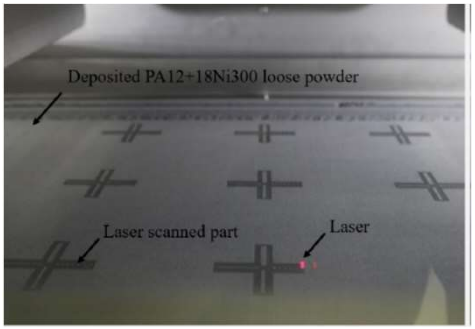
DSC of PA12

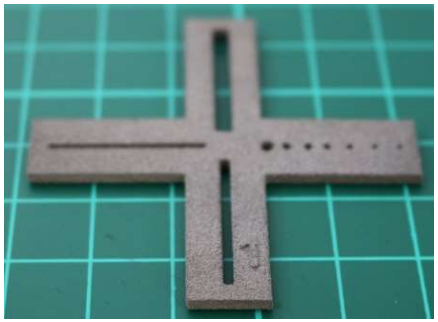


BET of powder maraging stell



Visual aspects of samples after debinding and vacum sintering process: a) 20wt.% binder, b) 10wt.% binder and c) 4 wt.% binder (26%vol.)





After sintering (N_2 atmosphere)

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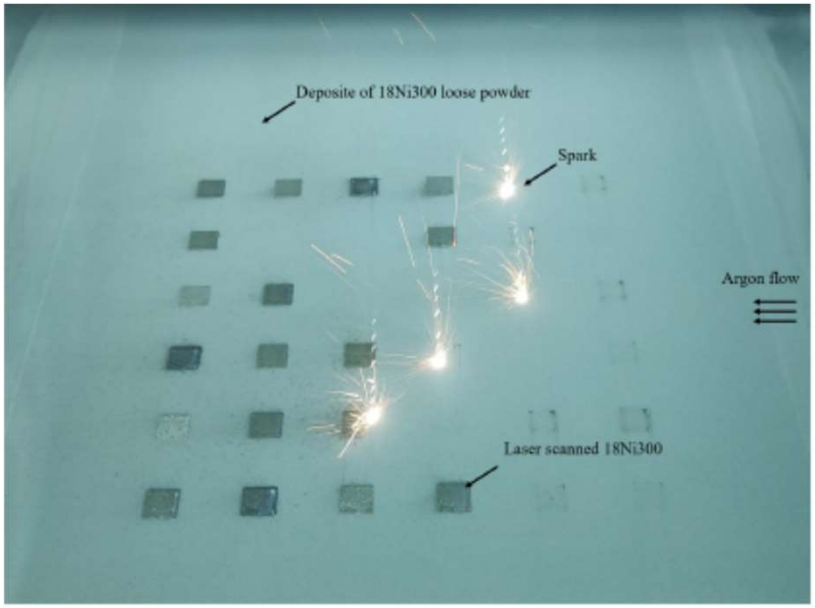
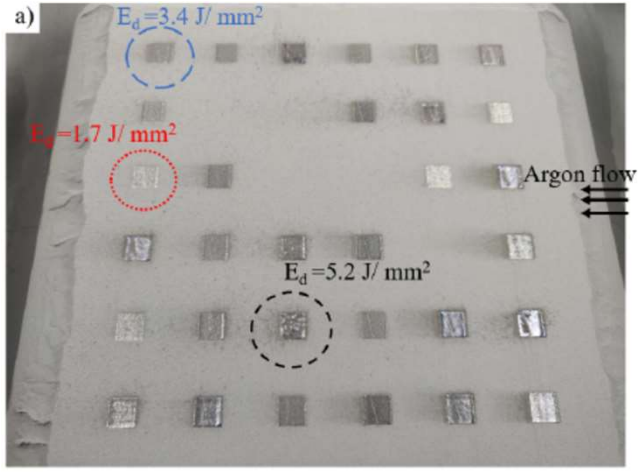
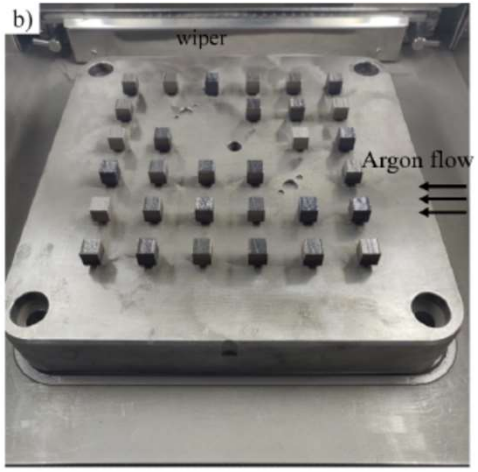
Metal parts for injection moulds by SLS/SLM

Direct SLM



Renishaw AM 500Q maraging steel processsing





After SLM processing: a) before powder removal, b) after powder removal.

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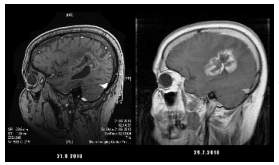
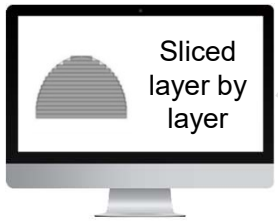
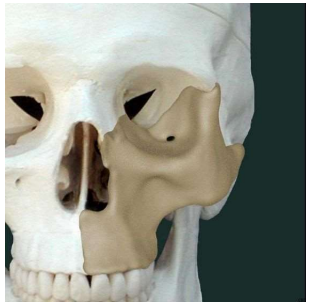
Bioactive glass scaffolds by 3DP, FFF and R3D



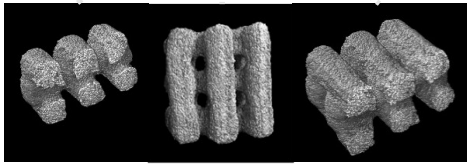


Models

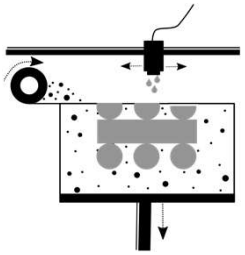


3D Fab

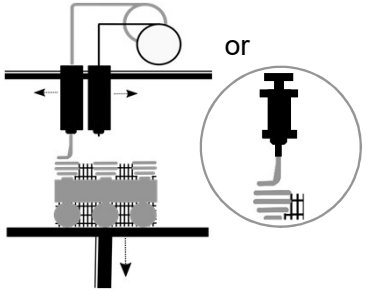
Customized scaffolds

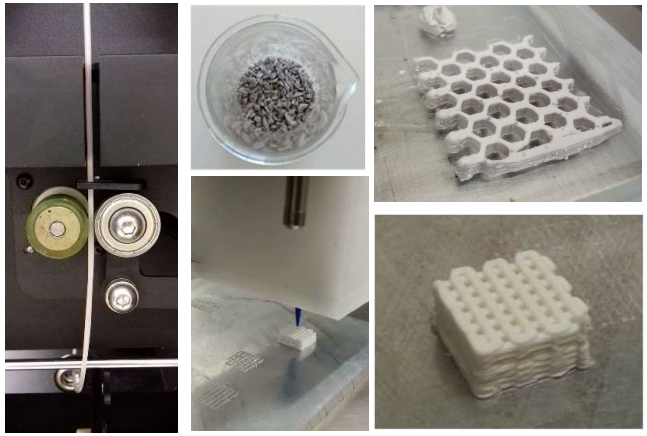


Binder jetting (3DP)



Material extrusion (R3D/FFF)





L.S.O. Pires et al., Int J Adv Manuf Technol, 98 (9-12), pp: 2665-2676, **2018** (https://doi.org/10.1007/s00170-018-2369-z)
L.S.O. Pires et al., J Therm Anal Calorim, 134 (3) pp: 2115-2125, **2018** (https://doi.org/10.1007/s10973-018-7307-7)

Bioactive glass scaffolds by 3DP, FFF and R3D

Fused Filament fabrication (FFF)

Prusa i3 MK3

Robocasting (R3D)

3D-Bioplotter developer - EnvisionTEC

Filament calibration for FFF

Materials

PLA

PLA/30GT14P43

ØFilament: 1,75mm

Manufacturing in oily medium

Materials

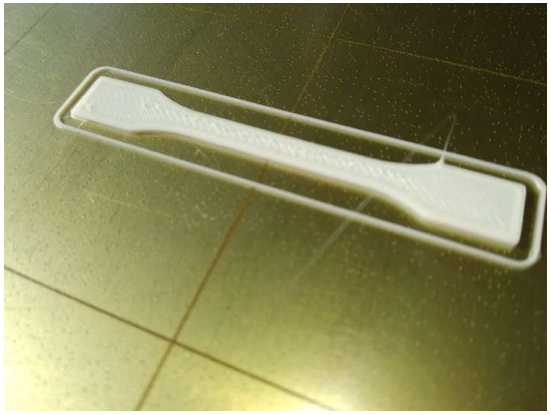
Powder: T14P43 (50%wt.)

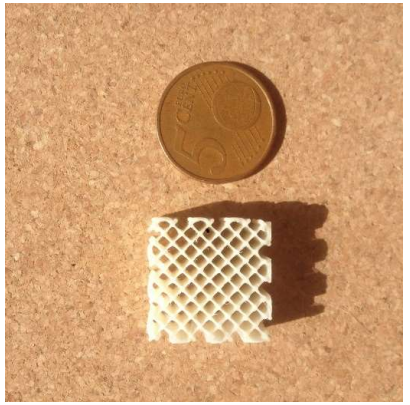
+

Additives:
Pluronic® (20%wt.) + H_2O (30%wt.)

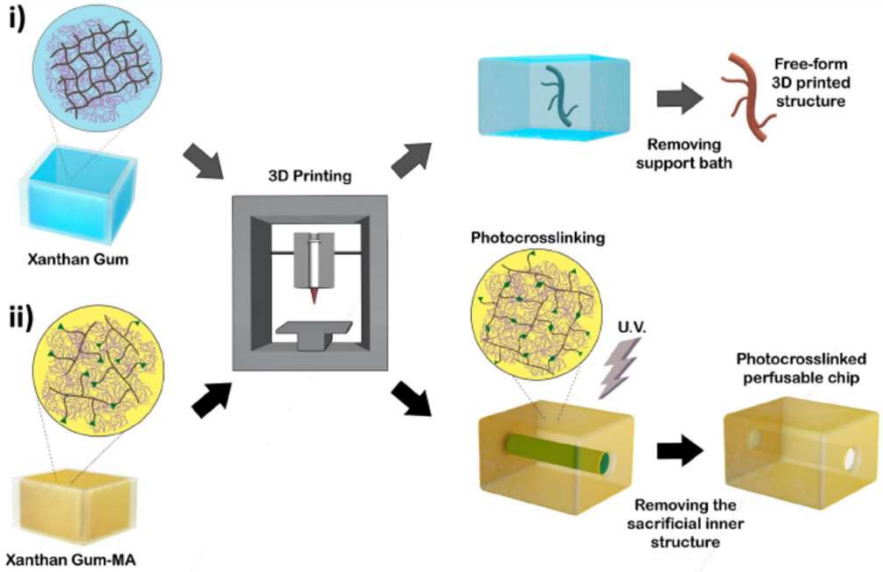
Bioactive glass scaffolds by 3DP, FFF and R3D

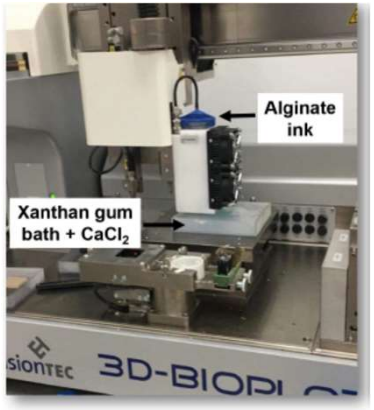
Hydroxyapatite filaments for scaffolds
Matrix: PLA (20%wt)

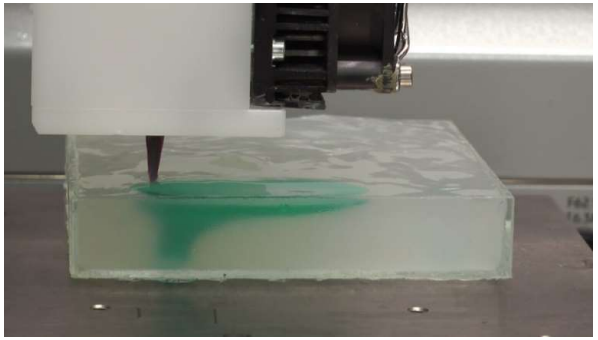


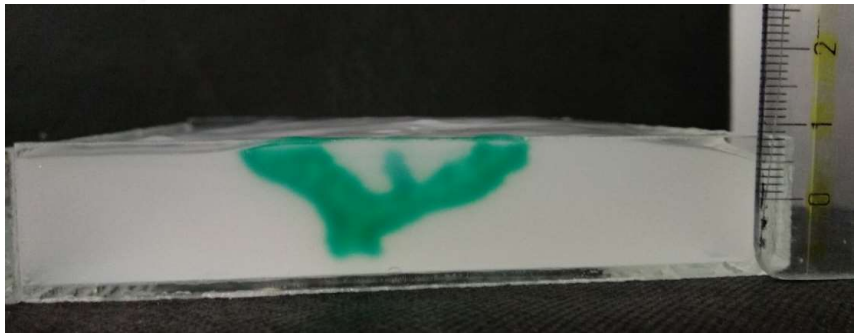


gel structures by R3D









Project with Compass group (Professor João Mano)

PrintCer3D: AM of porcelain products by 3DP

Goals

- Exploring 3DP as an alternative technology for ceramic production.
- Reducing manufacturing time
- New markets
- Manufacturing of parts with complex geometries (that are not possible to obtain through conventional manufacturing techniques).

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PrintCer3D: AM of porcelain products by 3DP

3D Printed tests with different binders

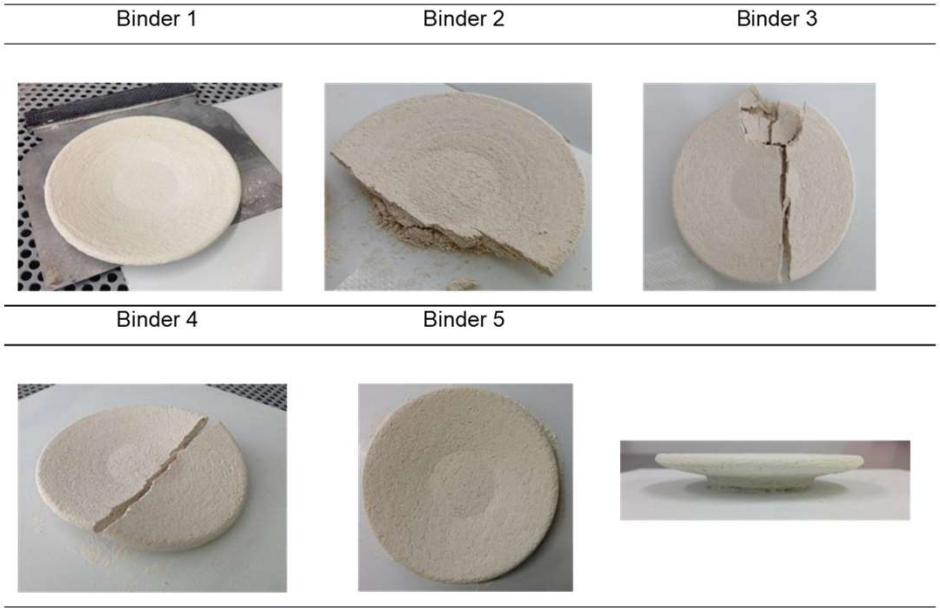

Table 1 Composition of binder formulations

Material	Binder 1 (wt%)	Binder 2 (wt%)	Binder 3 (wt%)	Binder 4 (wt%)	Binder 5 (wt%)
Sucrose	15	15	15	15	15
Glycerol	2	4	4	8	8
Ethanol	2	2	4	4	8

PrintCer3D: AM of porcelain products by 3DP

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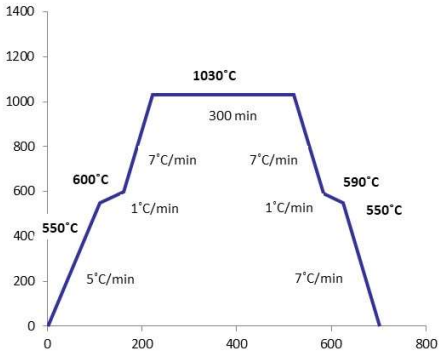
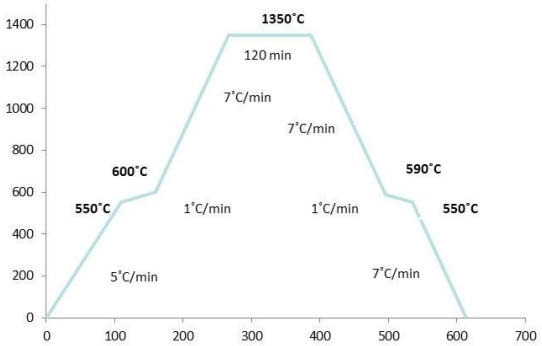
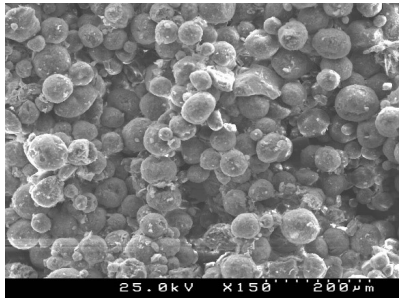
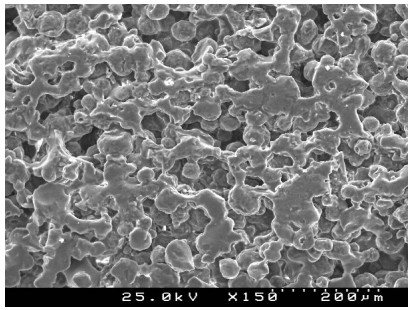
PrintCer3D: AM of porcelain products by 3DP

Heat treatment









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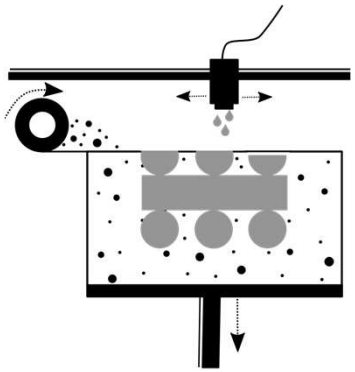
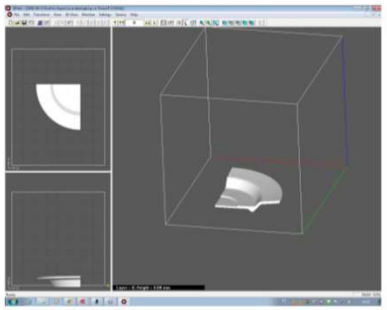
PrintCer3D: AM of porcelain products by 3DP





- Powder selection
- Powder distribution
- Flowability
- Contact Angle
- Binders
- Printer parameters

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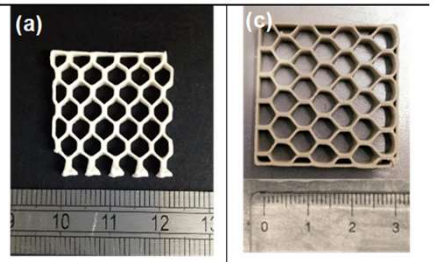
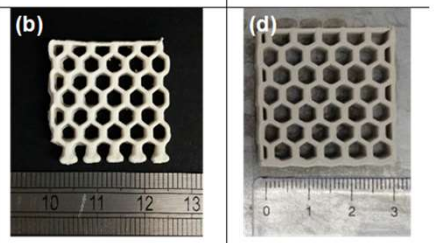
Robocer3D: AM of porcelain products by R3D

Goals

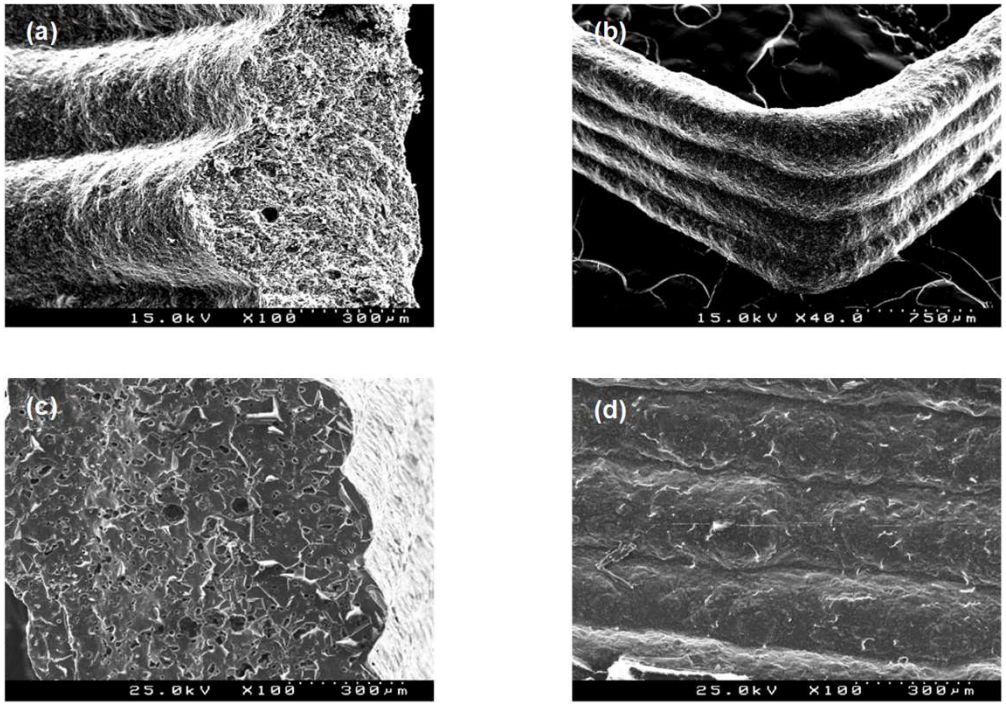
- Exploring R3D as an alternative technology for ceramic production.
- Developing industrial ceramic pastes with rheological properties matching R3D requirements
- Reducing manufacturing time
- Rapid Fabrication of 3D products with complex geometries
- New Markets

Robocer3D: AM of porcelain products by R3D

Pressure (bar)	Speed (mm/s) 10
2	
2.5	

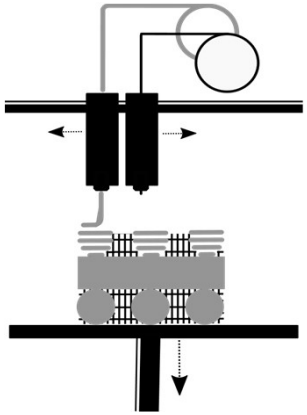
Operating process parameters to manufacturing 3D model: sintered honeycomb structures (a, b) and green honeycomb model with contour (c,d)

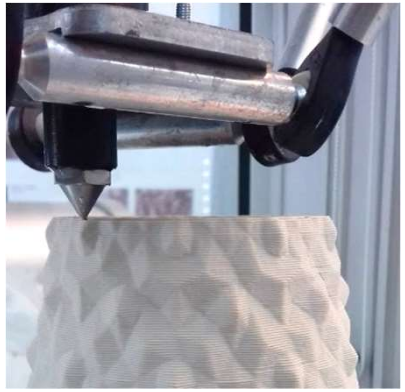
R3D tests and SEM



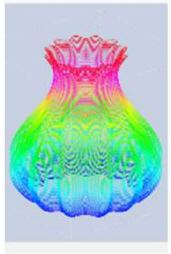
SEM micrographs on top surface and fracture of green (a, b) and sintered (c,d) model manufacturing with 2.5 bar and 10 mm/s

Robocer3D: AM of porcelain products by R3D





- Powder selection
- Powder distribution
- Viscosity
- Printer parameters
- Filament quality



RoboCer3D

Robocer3D: AM of porcelain products by R3D

Problems

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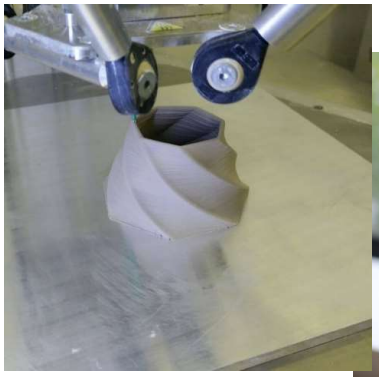
universidade de aveiro

CTCV

RoboCer3D

Robocer3D: AM of porcelain products by R3D



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RoboCer3D

Robocer3D: AM of porcelain products by R3D

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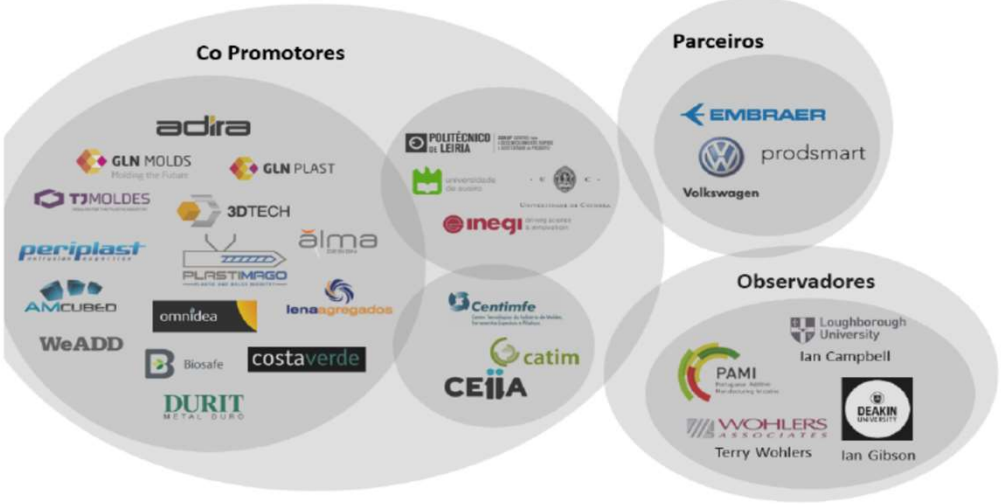
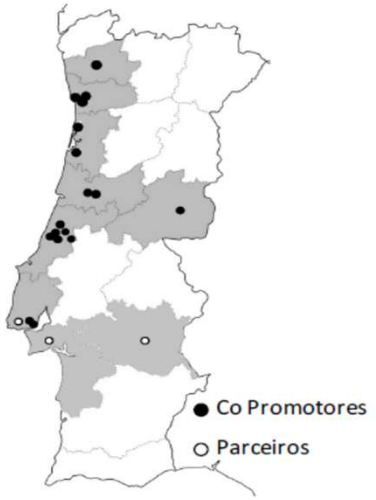
Add.Additive - add additive manufacturing to Portuguese

Add. consortium | consórcio





PROGRAMA MOBILIZADOR 2017-2020

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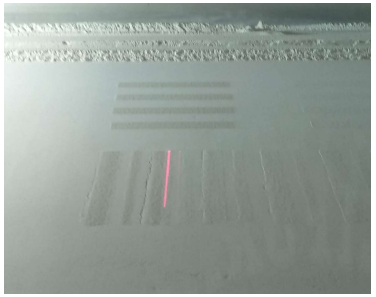
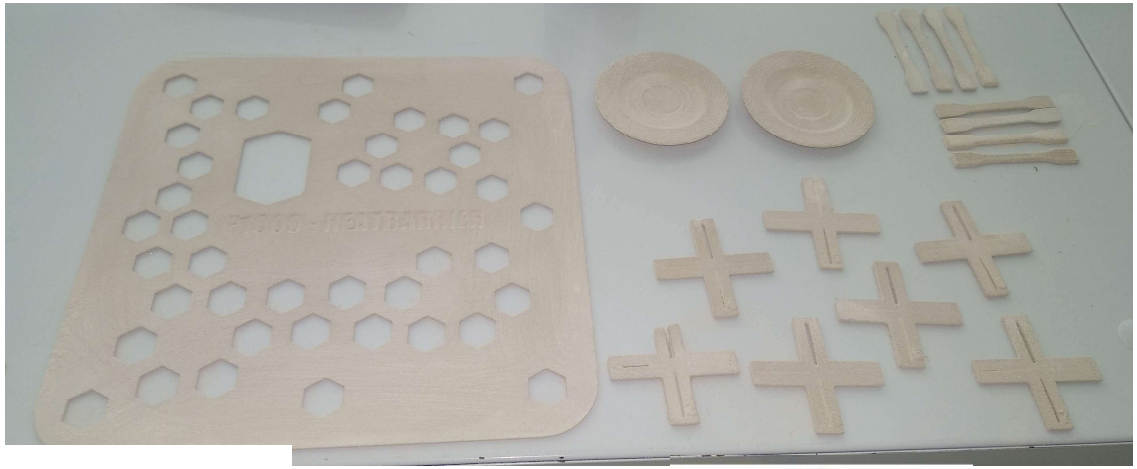
Add.Additive: Indirect SLS of porcelain powders





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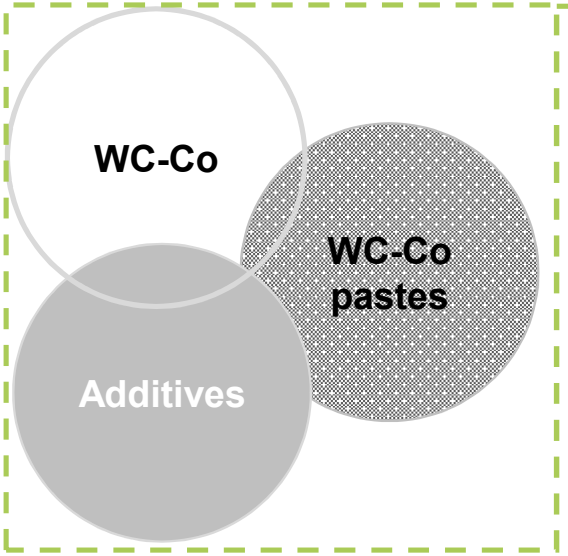
Add.Additive: robocasting of WC

- WC pastes with customized properties based in industrial WC-Co formulations
- Introduction of AM technology
- Post processing steps optimization

✚ free form | small batch | customized products

▬ moulds | manufacturing time and costs | waste material



*industrial WC-Co powders
*additives: Metamax l-15 and Pluronic F127

Powder selection

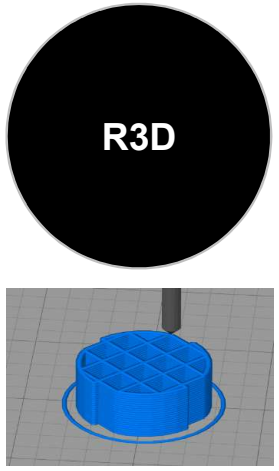
Mixture

Characterization (e.g.: Coulter; XRD; SEM; Rheology)

Robocasting 3D: process parameters

WC-Co powder

Additive Manufacturing



*R3D: Robocasting

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Add.Additive: robocasting of WC

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AM – it´s time to produce!

Martinho Oliveira (martinho@ua.pt)
EMaRT – Emerging: Materials, Research and Technology Group
Escola Superior Aveiro Norte, Universidade de Aveiro
Estrada do Cercal, 449
3720-509 O. Azeméis
Tel. [+351] 256 666 960