LAAS Days
Research & Technology

2D-3D Bioprinting for medical microdevices

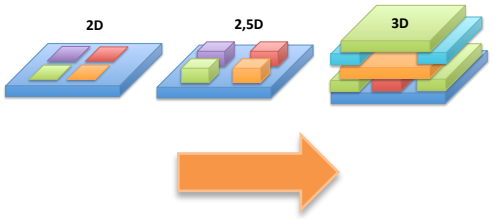
Alive Strategic Axis

Laurent Malaquin

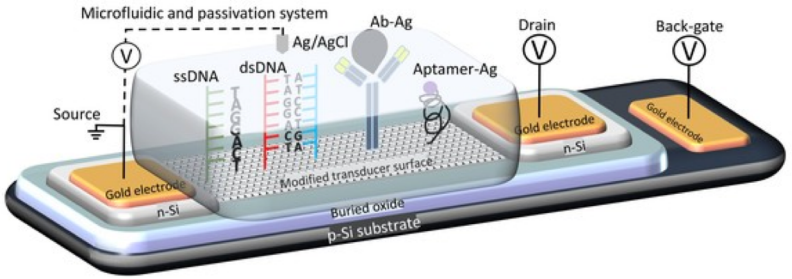
What does bioprinting means ?

> Integrating biological functions into microdevices

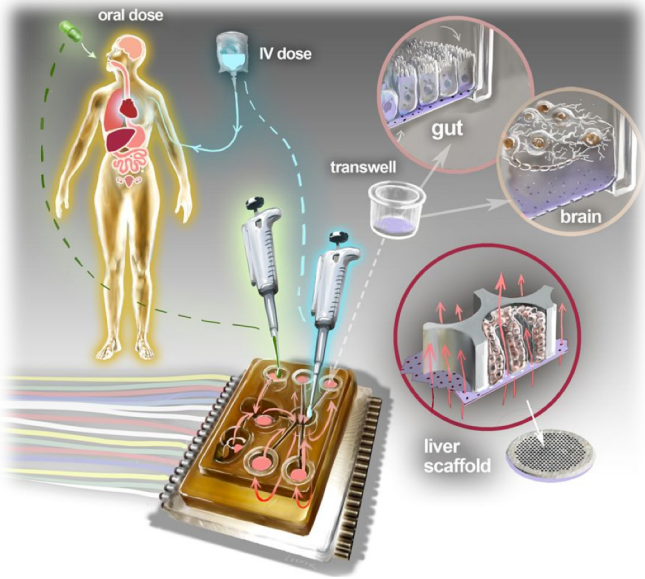
- Biomolecules
- Biomaterials
- Living cells
- « Vascular » structures
- Mechanics, topology



Biomarker Detection
Biomarker Analysis
Cell capture an sorting
Cell biology

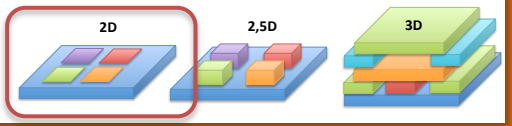


Biosensors
(Subash et al. Biosens. Bioelec. 2017)



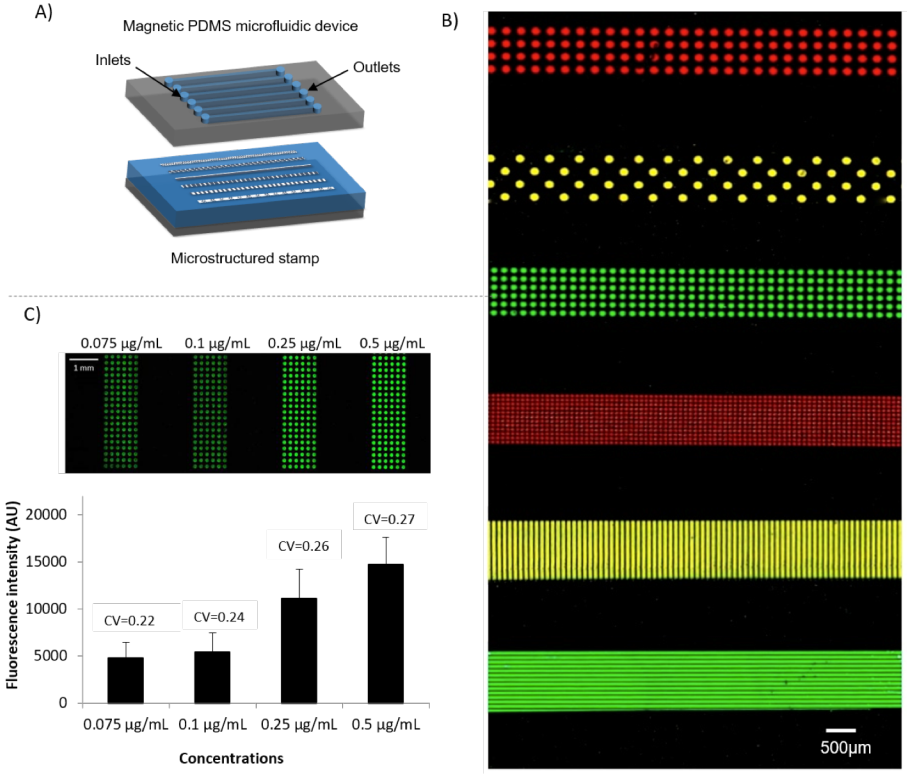
Microphysiological systems
(Edington et al., Nature 2018)

2D Biomolecular printing



> Microcontact printing (µCP)

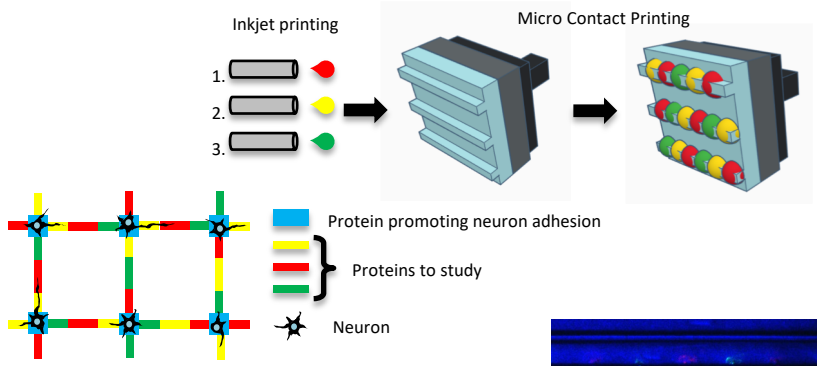
Multiplexed and automated protein deposition on flat surfaces for bioassays

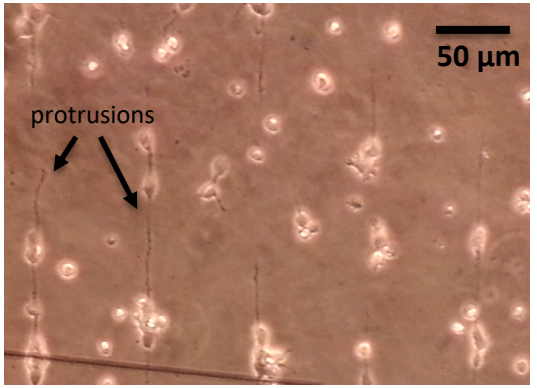


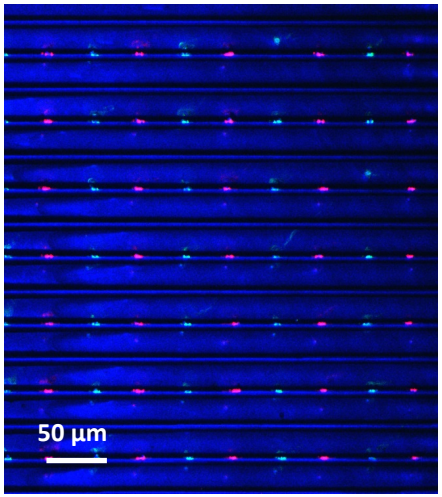
J.Foncy & A.Esteve et al, Plos One 2018
J.Fredonnet et al, Microarrays 2016
A. Esteve, MEE 2018

> Inkjet technology

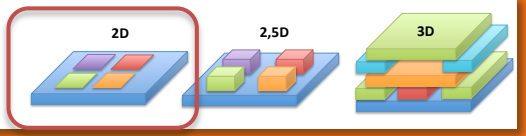
Coupling inkjet with µCP to creating protein patterns for directed neuron growth





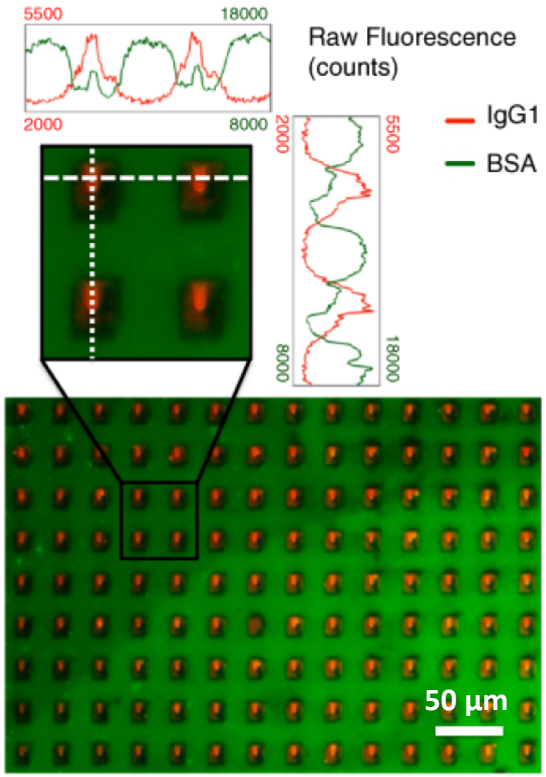


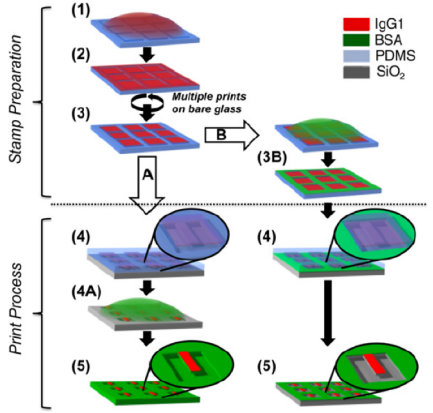
Integrating bioactivity in sensors



> Tailoring sensor surface

Micro contact printing of antibodies on vibrating micro/nanocantilevers



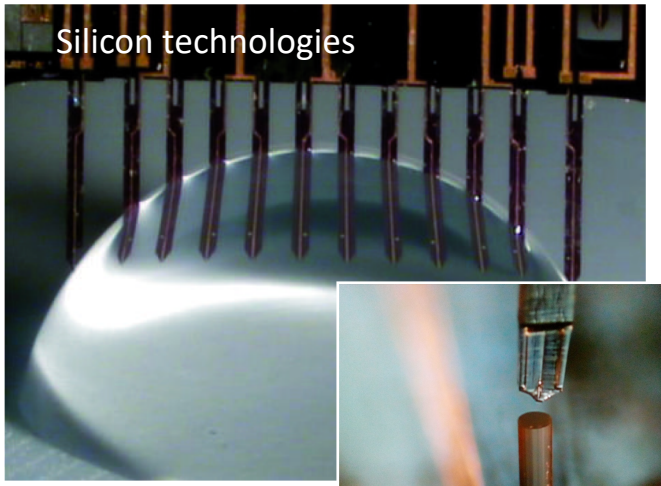


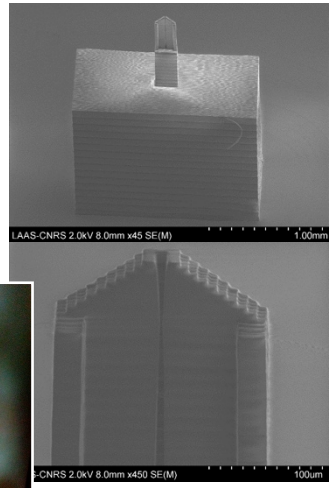
Salomon et al, Nanotechnology, 2012

T. Lechlé et al. Journal of MEMs, 2008 / ANR Moly (2016-2019)

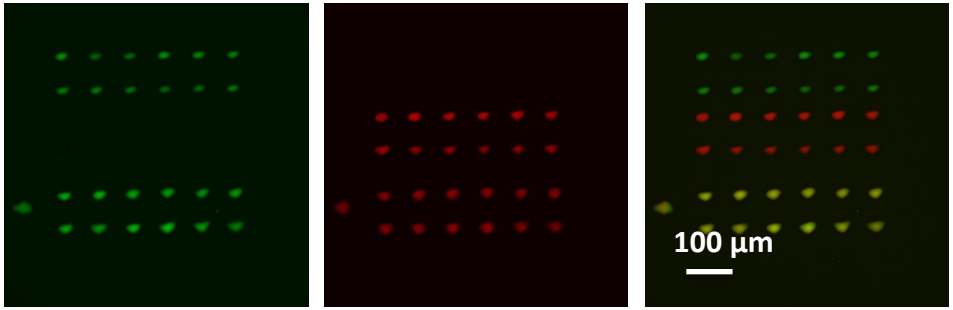
> Bioplume technology

Multiplexed DNA/protein deposition on surfaces and microdevices (optical fibers)

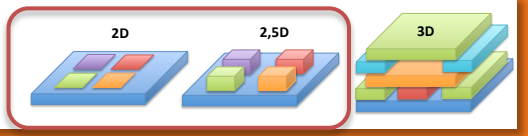




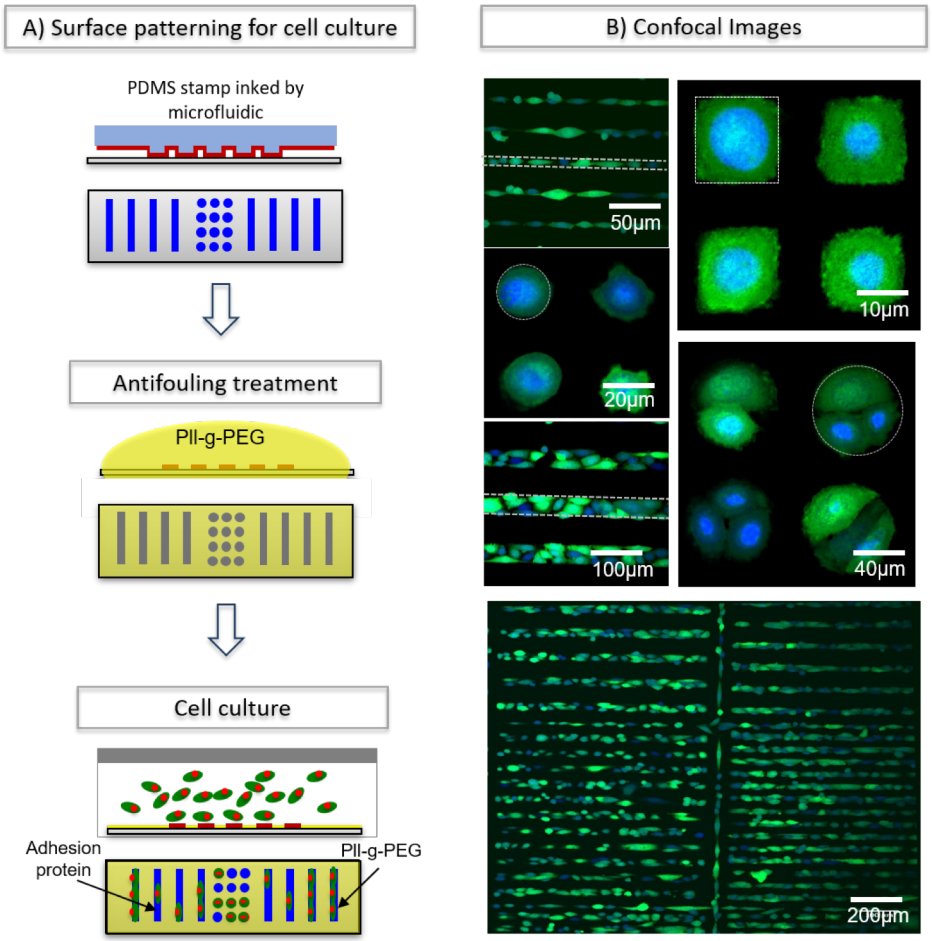
3D printed bioplume



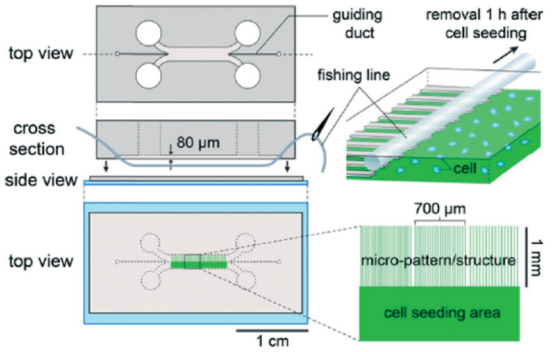
Cellular capture and guidance



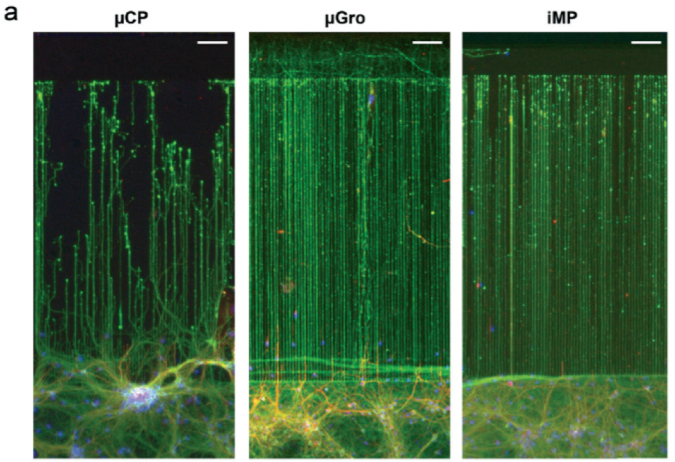
> Controlling cell shape, position, growth



Foncy, Esteve et al, Plos One 2018

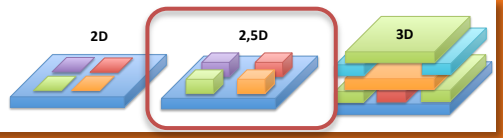


Microcontact printing and molding for cell capture and Neuron Guidance on 2D / 2.5D protein patterns

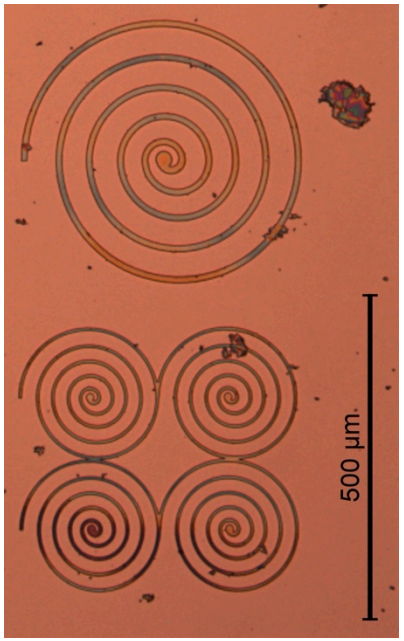


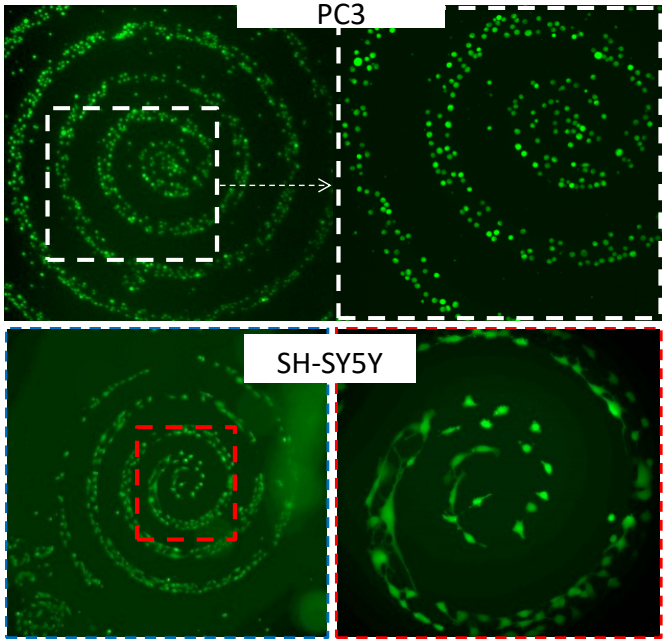
Yamada, A. et al. Lab Chip 16, 2059–2068 (2016).

Biomaterial patterning

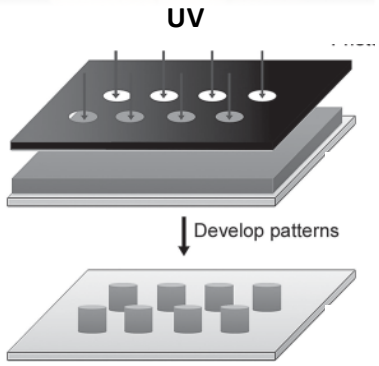


> Developping photosensitive biomaterials

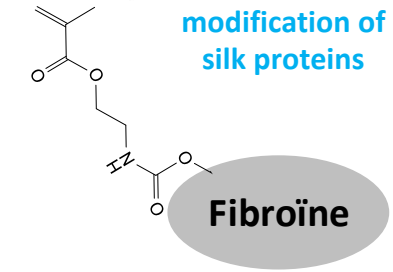




Silk Cocoons



Chemical modification of silk proteins

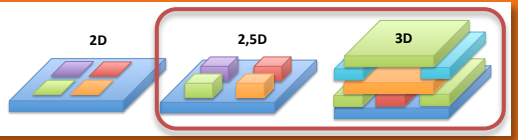


Photolithography

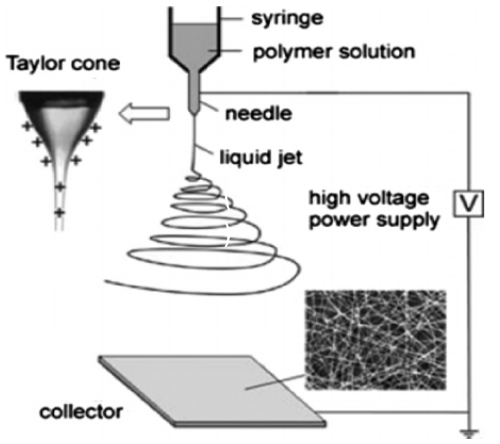
Development of photosensitive silk protein based material for cell culture in controlled stiffness conditions

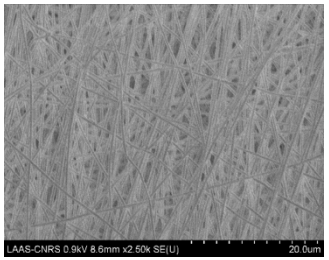
Maziz et al. Submitted to Biofabrication, 2018

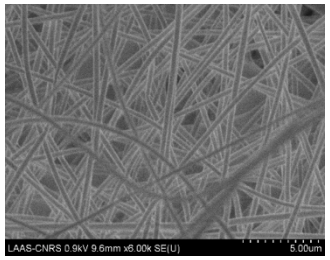
Shaping biomaterials in 2D/3D

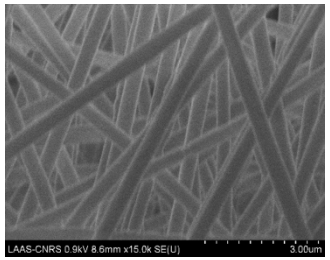


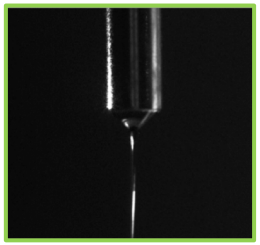
> Electrospinning

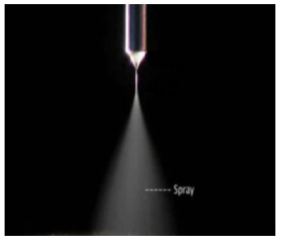








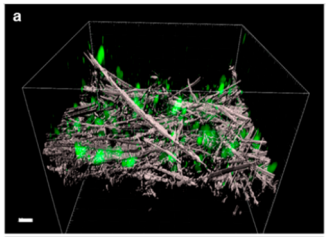


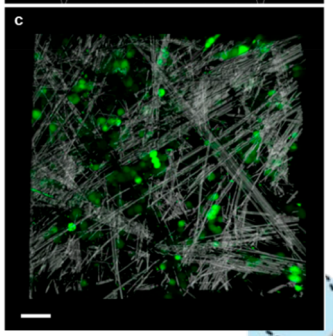


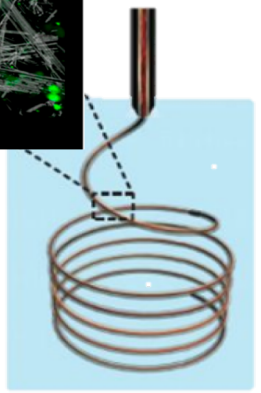
Fabrication of silk/PEG fibers or drolets with diameters ranging from 150 nm up to 4 µm

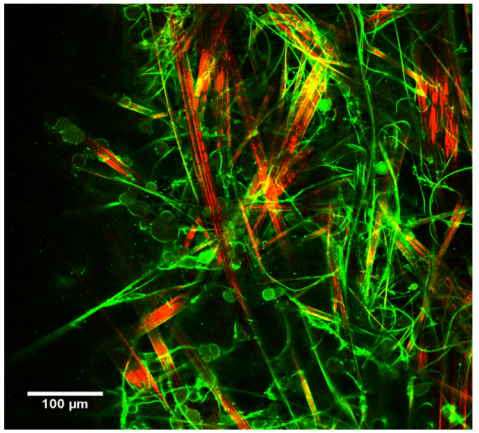
A. Maziz, C. Bergaud
A.Chalard et al, ACS Applied Materials and Interfaces, 2018

> Wet spinning (solvent exchange)



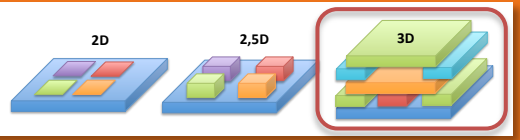




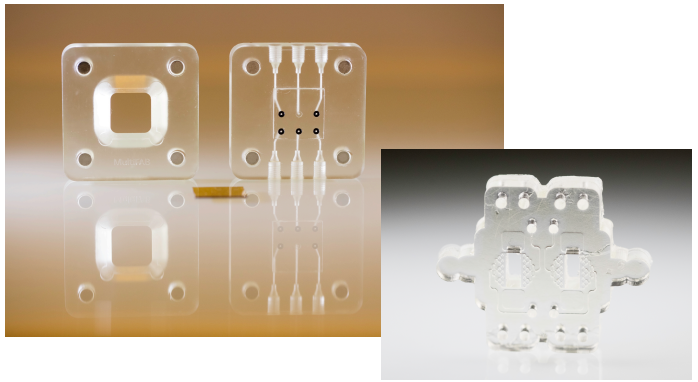


Fabrication of macromolecular Alkyl-galactonamides hydrogels fibers (100-500µm) for neuron cell culture.

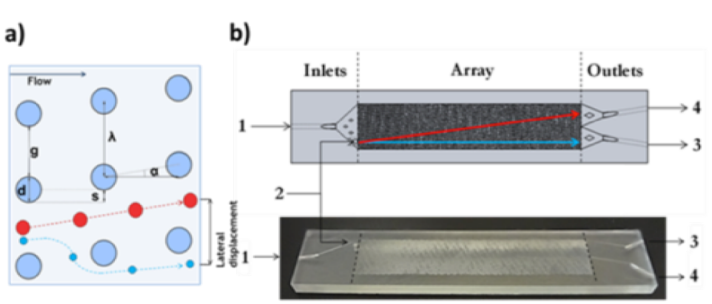
3D Printing functional devices

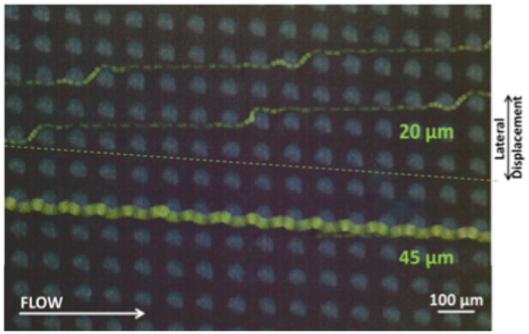


> 3D printed microfluidic devices for biomarker analysis and cell sorting

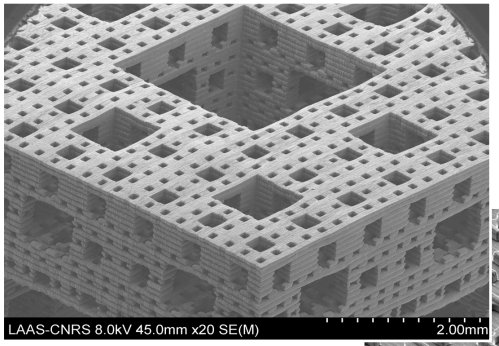


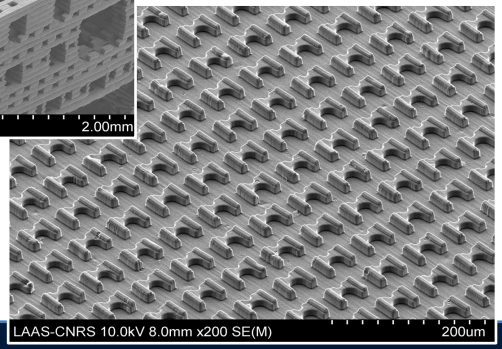
- Sorting of cells and particles (Deterministic lateral displacement)



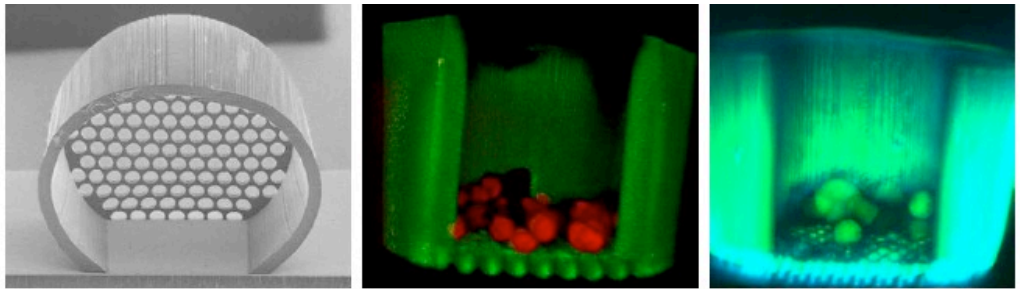


- Sorting CTC with 3D printed filters



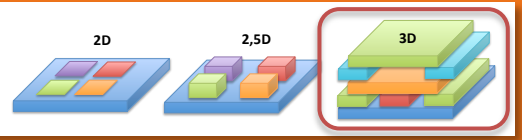


High resolution (<1 µm)
Complex 3D structures



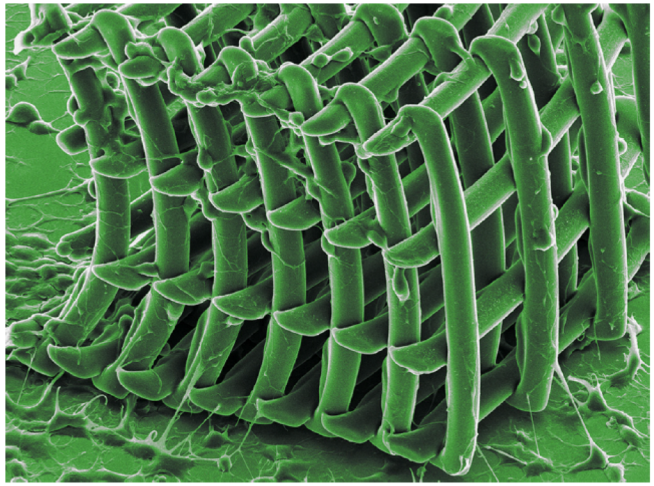
F.Mézières et al, JASA 2016
A.Accardo Add. Manufact. , 2018
A. Cerf, A. Esteve, K. Jimenez

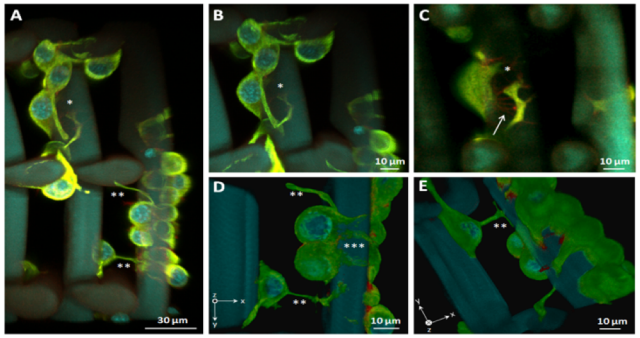
3D model systems for cell biology



> Controlling the topology and mechanical properties of cell microenvironment

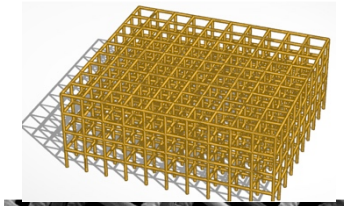
- 3D scaffolds for neuron cell growth

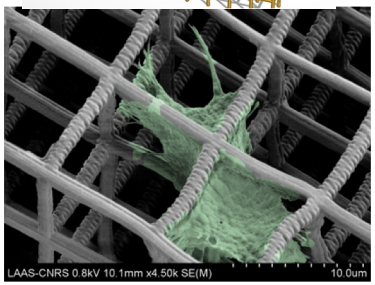


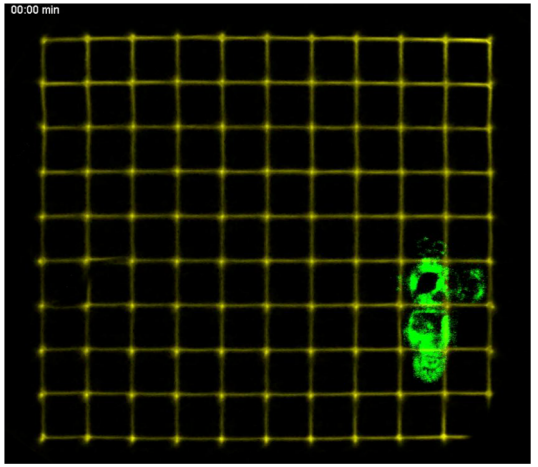


Accardo et al, Materials Today, 2018
Acardo et al Small, 2017 / E. Desvignes
M. Delarue et al, Nature Physics, 2017

- 3D models for cell migration studies

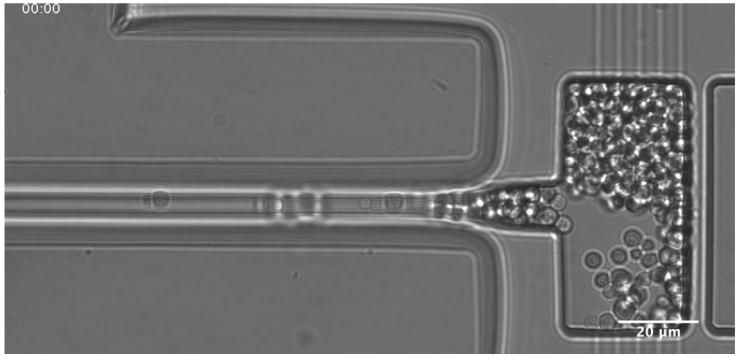




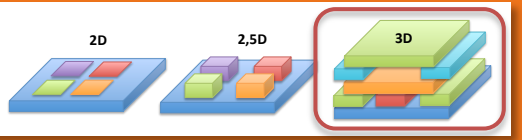


- Mechanical environment

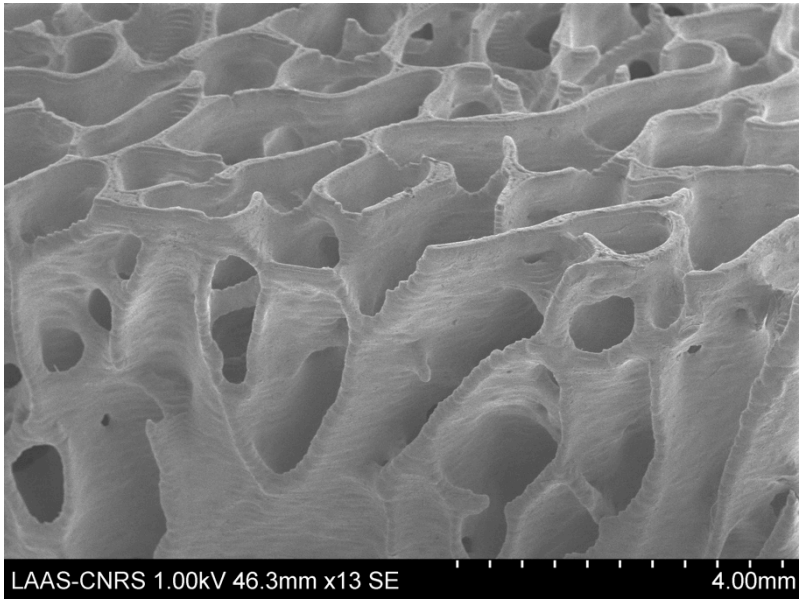
Controlling pressure, supply, confinement (yeasts)

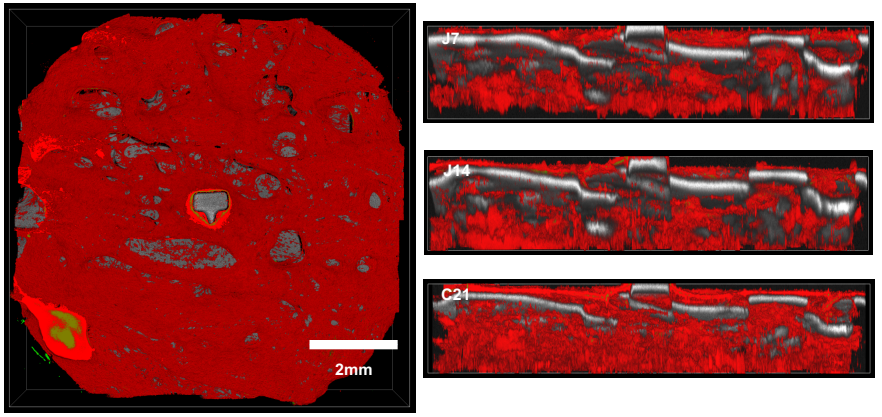


Controlling cell microenvironment



> Controling topological environment for cell culture

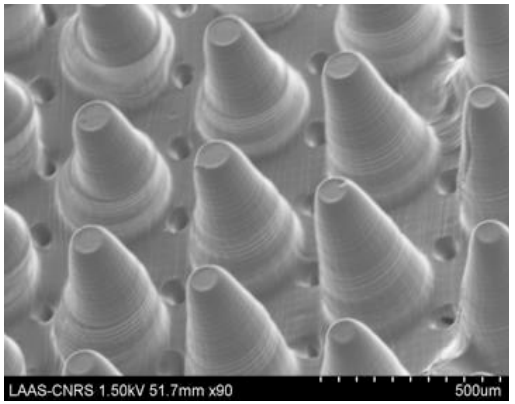


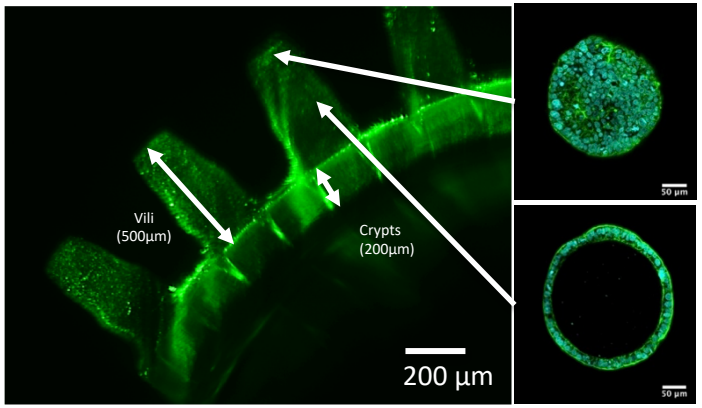


Growth and differentiation of Mesenchymal Stem Cell on trabecular bone scaffolds

- Controlling stiffness, topology, material chemistry of the microenvironement
- Controlling cell position by printing ?

- 3D models for oncology / regenerative medicine



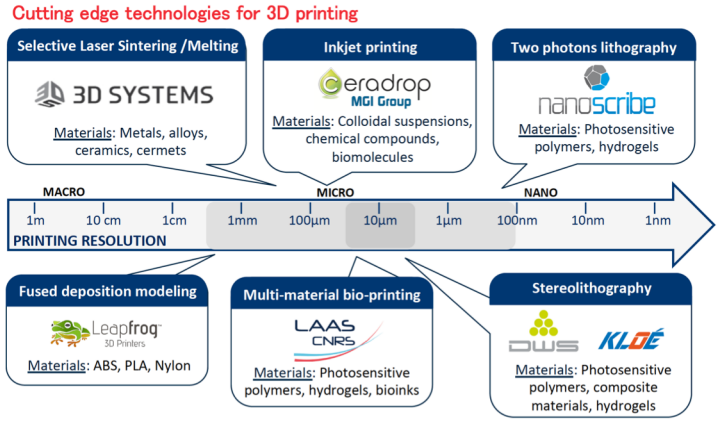


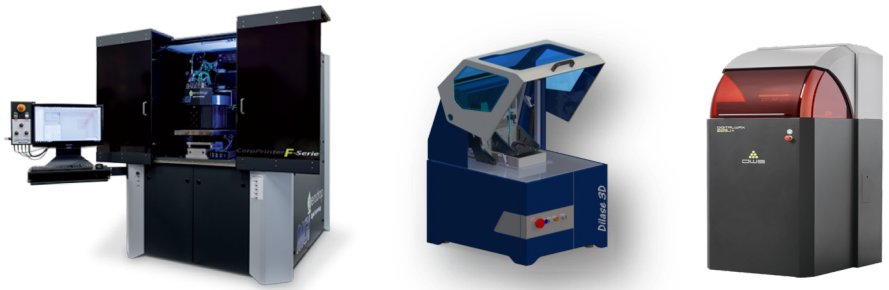
F. Mézières et al, JASA 2016
J. Creff, A. Besson

Academic and Industrial Transfer

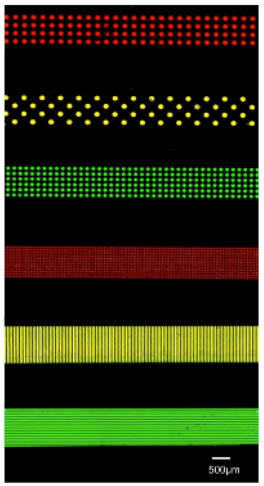
> MultiFAB platform

(LAAS-CNRS / CIRIMAT)

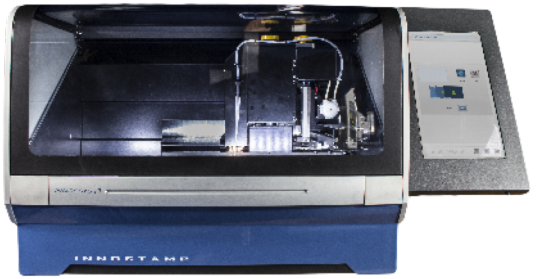




> Joined Laboratories



Multiplexed microcontact printing with reversible clamping



www.biosoftlab.com

https://www.laas.fr/projects/MultiFAB/

PROJET COFINANCÉ PAR LE FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL

2D to 3D Bioprinting

> *Novel opportunities for microdevices fabrication and integration*

> *An open field of research for cell biology*
- *Fundamental studies in cell biology*
- *Models systems for drug screening and diagnosis*
- *Regenerative medicine*

> Challenges :
- technological development
- material development