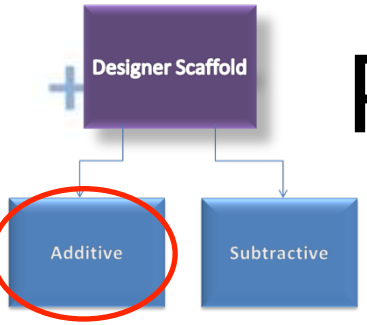
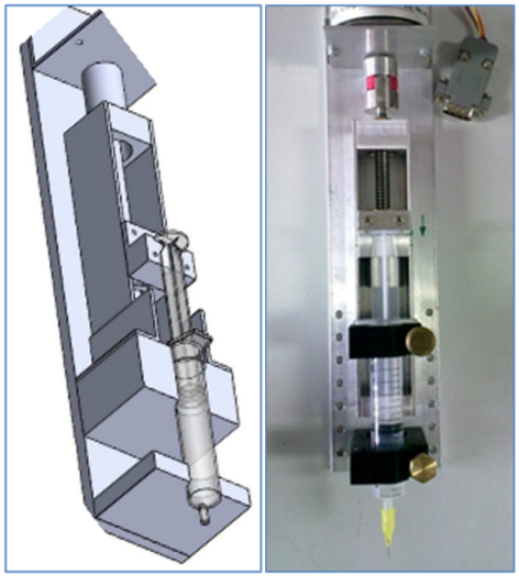
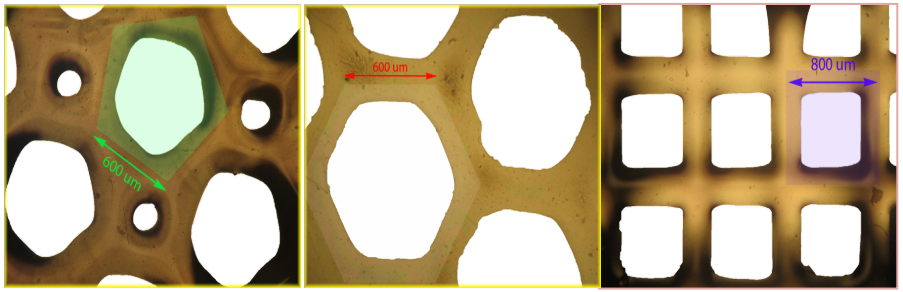
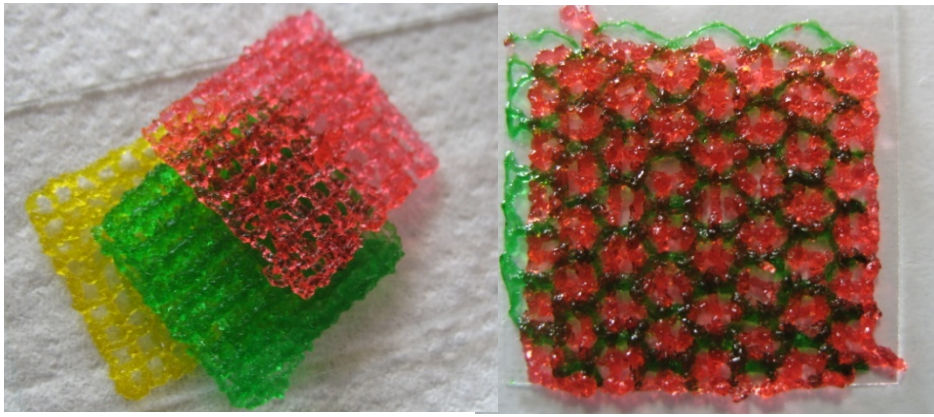


Piston Assisted Microsyringe (PAM2)

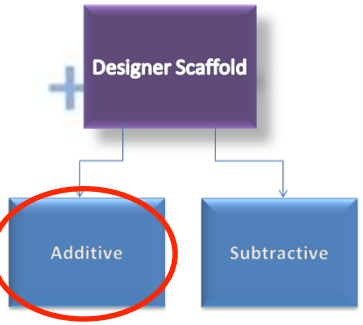
Plunger driven







Vozzi, G., Tirella. A., Ahluwalia, A., Computer-Aided Tissue Engineering, Springer (2010); Tirella, De Maria, Vozzi, Ahluwalia Rapid Prot. J (2012); Tirella, Orsini, Vozzi, Ahluwalia Biofabrication (2009),

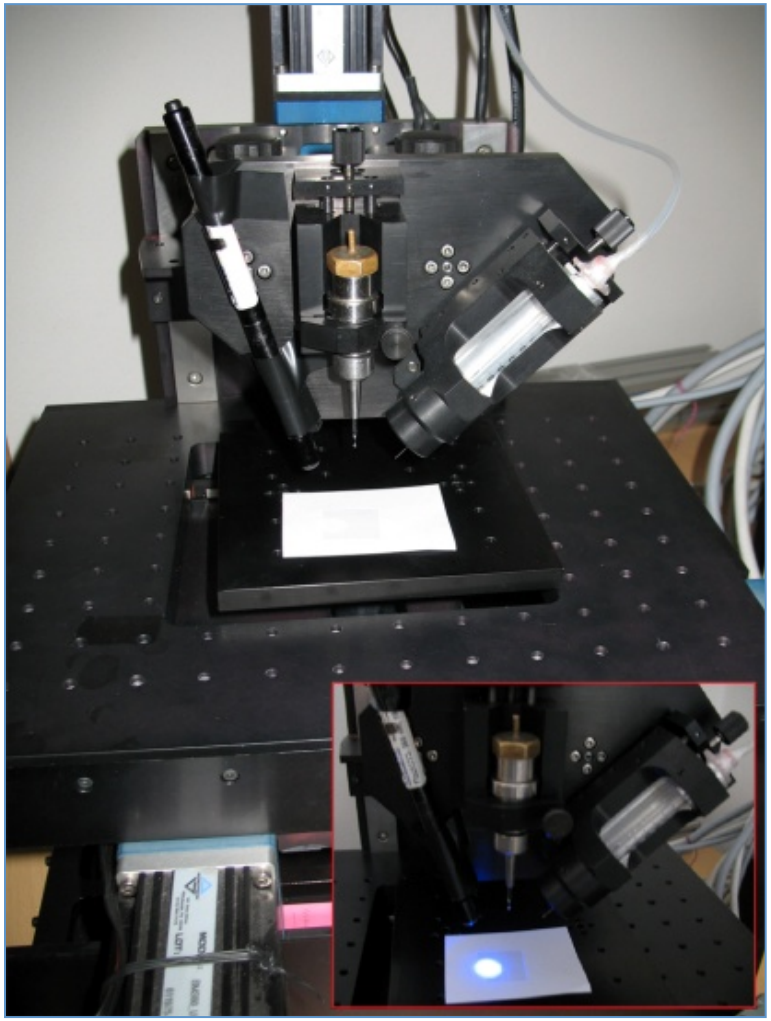


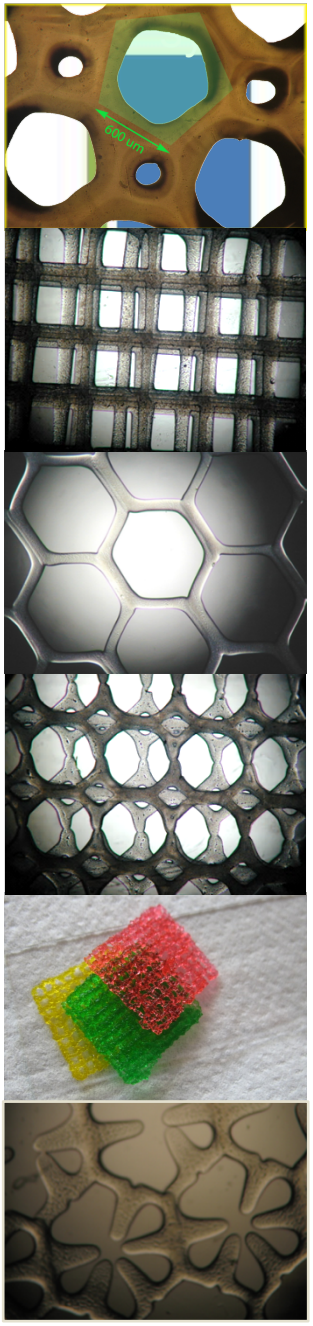
The PAM2 system

Robotic 3 axis micropositioner.

- ✓ PAM
- ✓ PAM2
- ✓ Diode laser
- ✓ Temperature control
- ✓ PAM^2 software

- 4 Position controlled brushless motors (resolution of 10 µm ± 1 µm)
- Working space 100×100×80 mm
- Working velocity 1-15 mm $\cdot s^{-1}$
- Design of *z*-stage to locate several modules

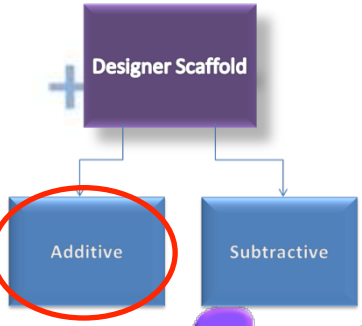


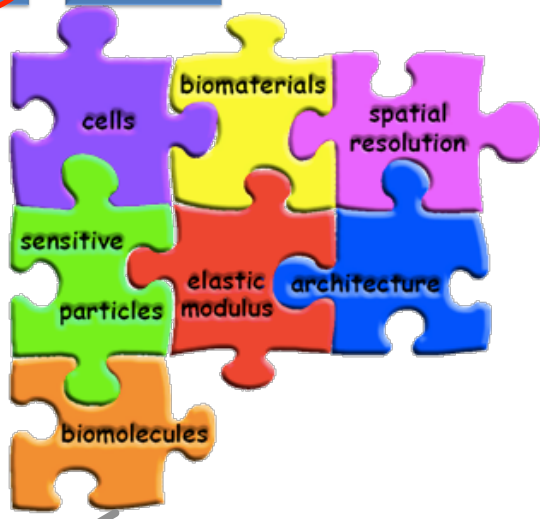


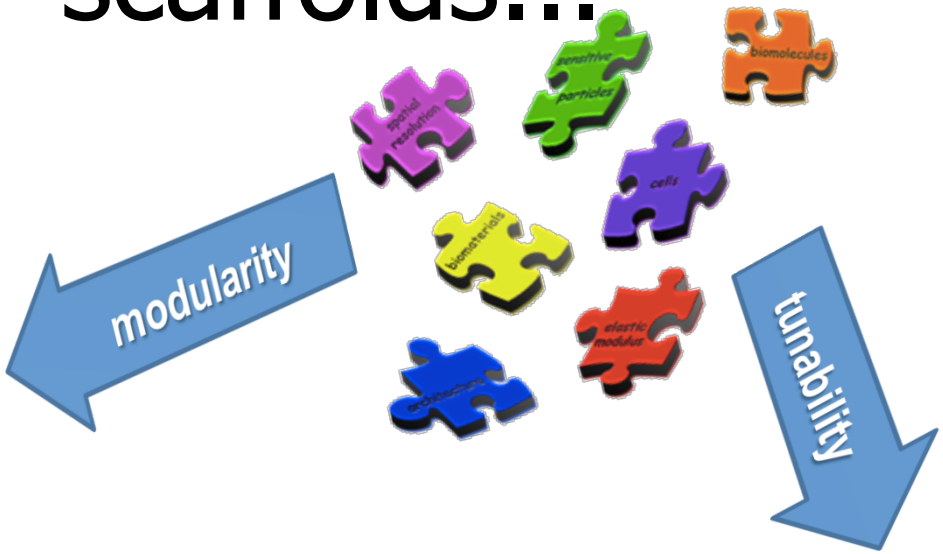
Materials?
Speed?
Price?
Fidelity?

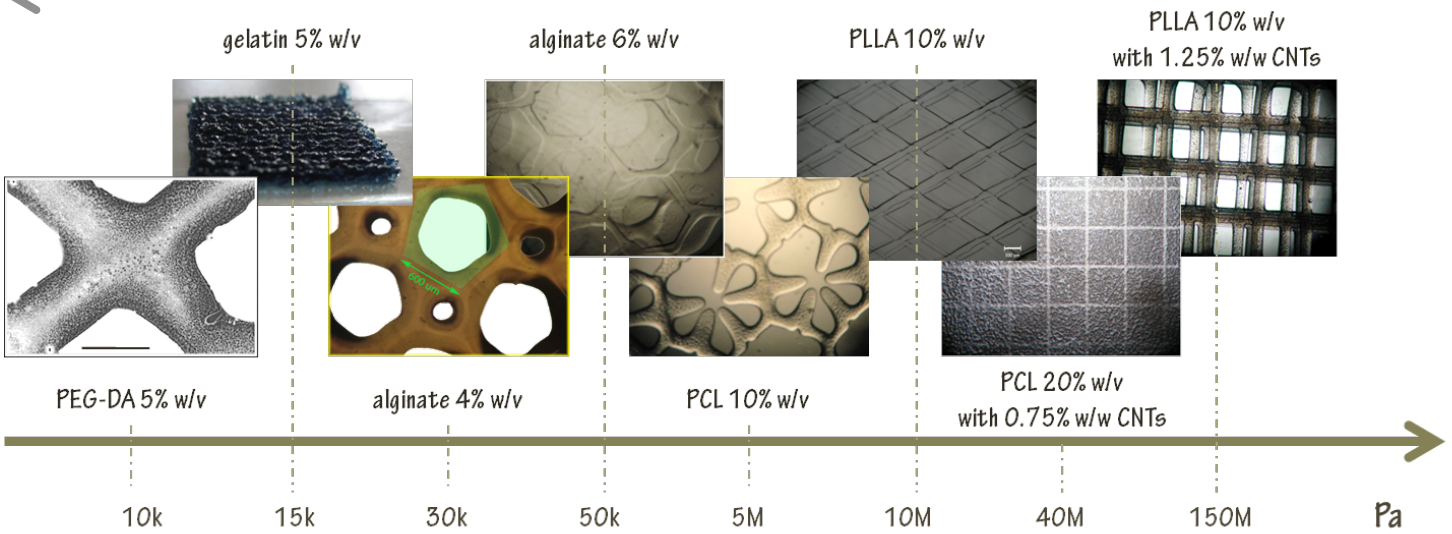
Tirella, De Maria, Vozzi, Ahluwalia Rapid Prot. J (2012);

Smart-tunable modular scaffolds…

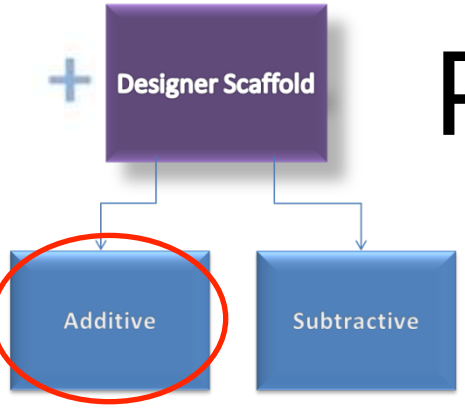




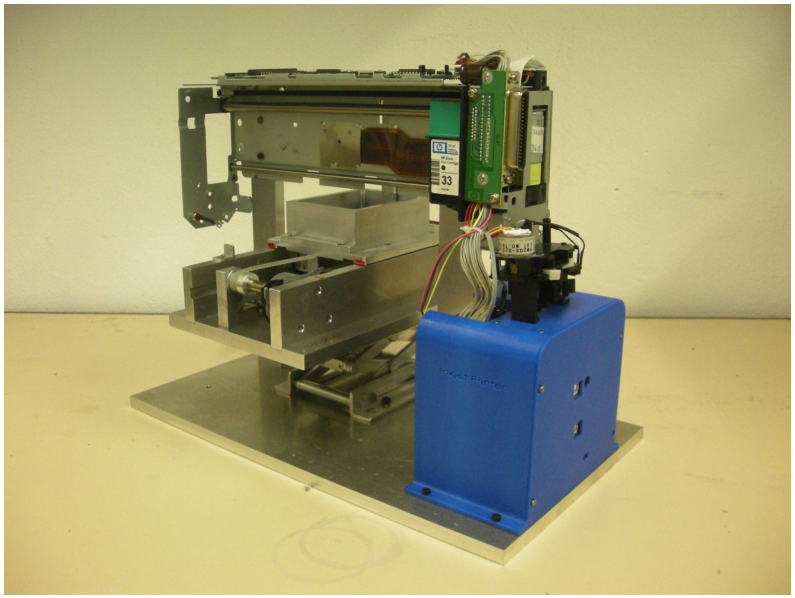


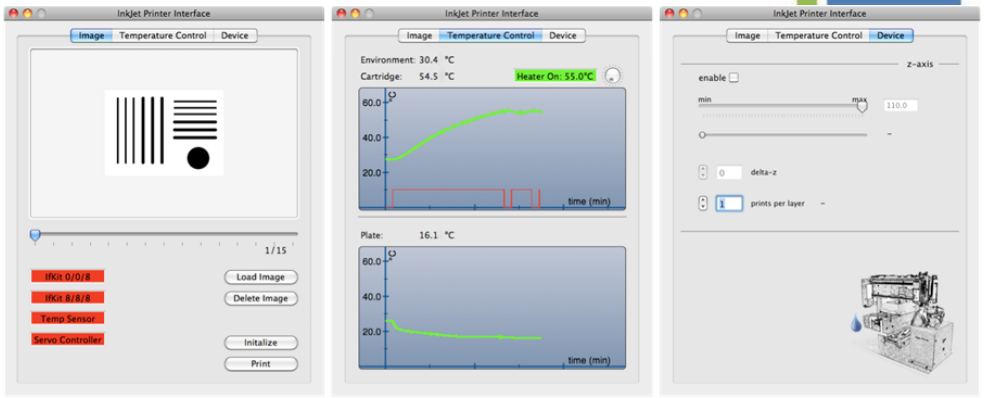


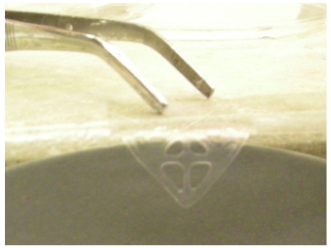
Development of a modular microfabrication system to engineer complex tissues

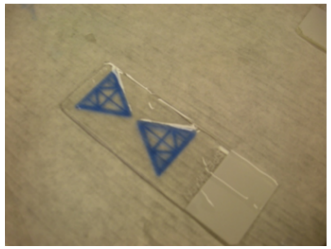


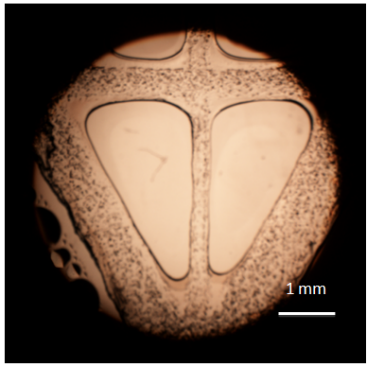
Penelope Ink-Jet printer



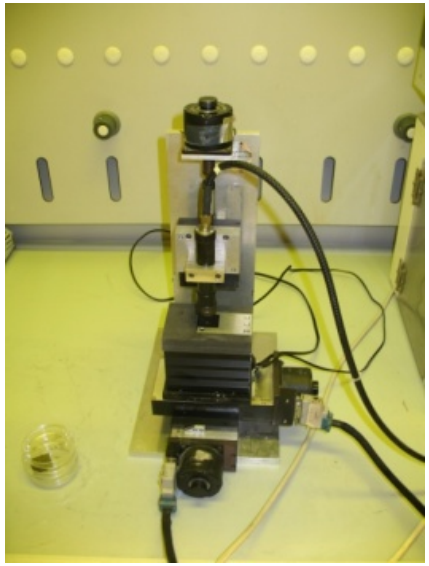








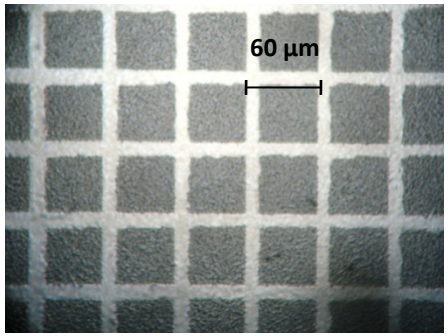
µLaser System



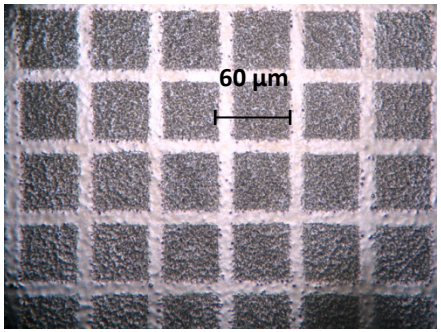
CAD/CAM system, 3-axes control of:

- position, ±25 mm;
- velocity, 0-4.5 mm/s;
- resolution, 1 µm;
- accurancy and repeatability.
- Thulium laser (1920 nm wavelength, 2W emission power):
- Control of power emission
- Layer-by-layer processing.

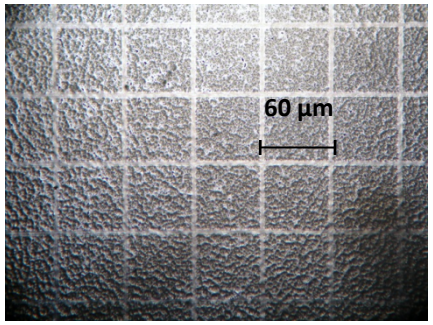
µLaser Structures



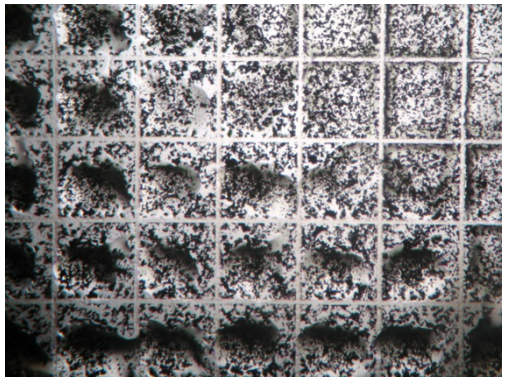
20 % PCL x-y velocity 1,25 mm/s



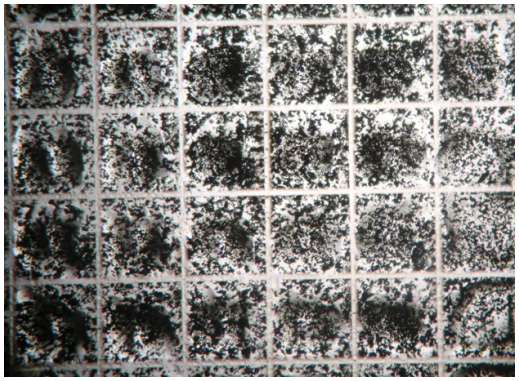
20 % PCL x-y velocity 2,15 mm/s



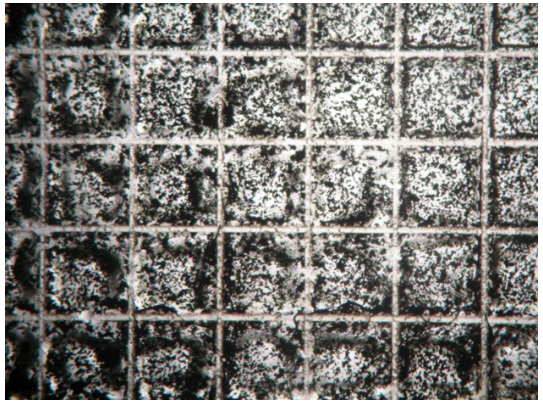
20 % PCL x-y velocity 3,34 mm/s



20 % PLGA+ 1.25% carbon black
x-y velocity 1,25 mm/s



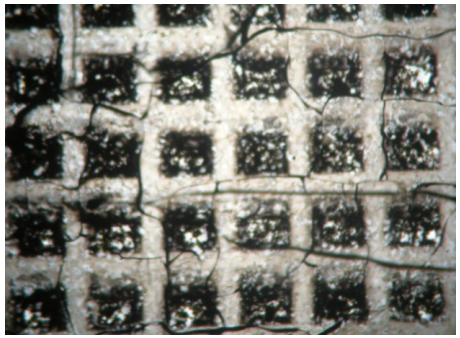
20 % PLGA+ 1.25% carbon black
x-y velocity 2.15 mm/s



20 % PLGA+ 1.25% carbon black
x-y velocity 3.34 mm/s

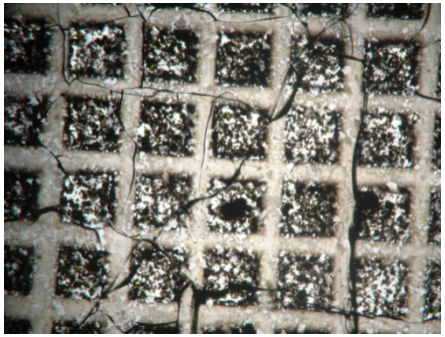
60 µm

µLaser Structures



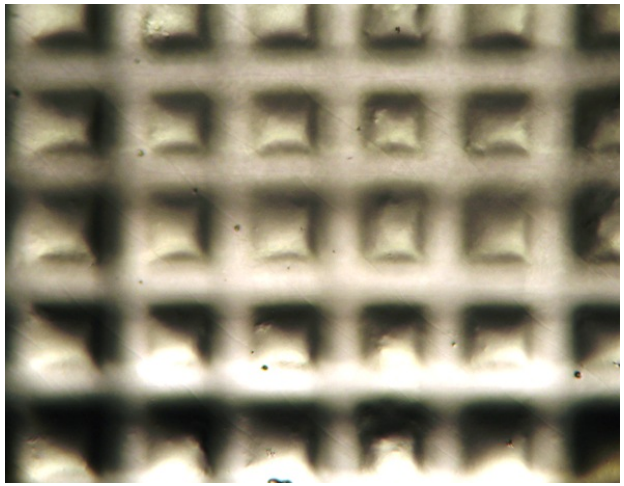
60 µm

20 % PLGA+ 1.25% carbon nanotubesk
x-y velocity 1,25 mm/s



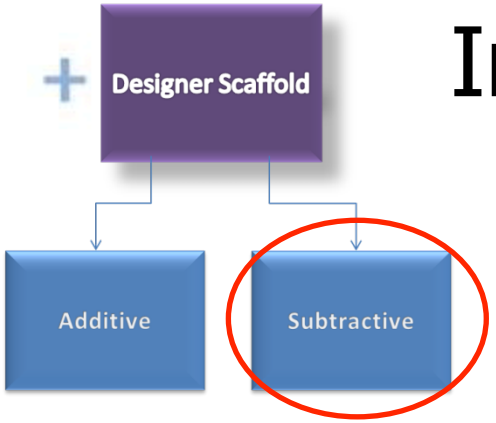
60 µm

20 % PLGA+ 1.25%Carbon nanotubes
x-y velocity 2.15 mm/s

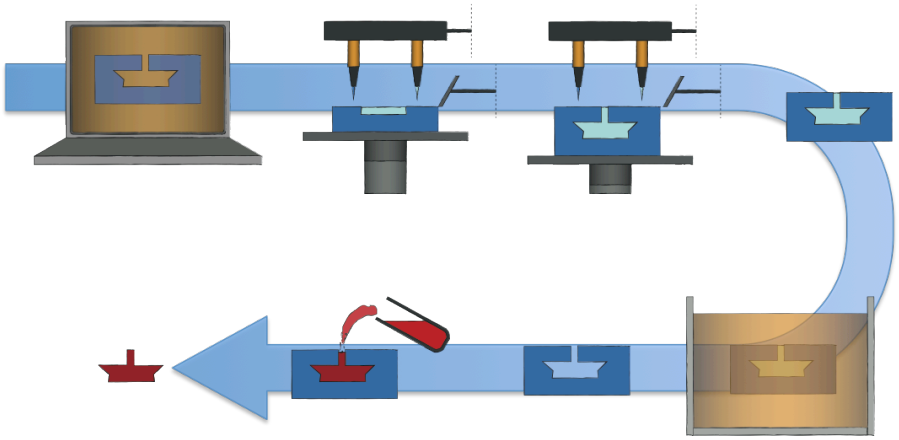


60 µm

1 % Agarose
x-y velocity 3.34 mm/s



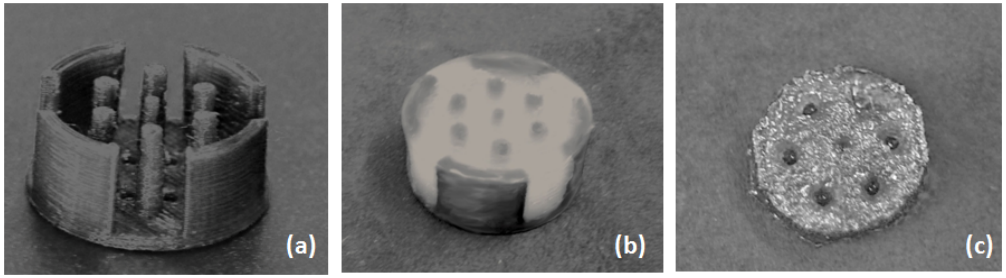
Indirect Rapid Prototyping (iRP)



- Molds realised with RP devices (CAD/CAM)
- Casting of the desired (bio-) material
- Extraction of the final object

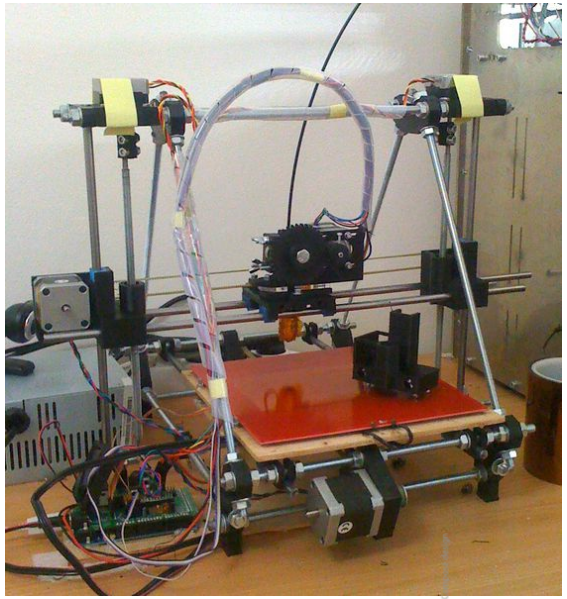
Advantages?
Limitations?

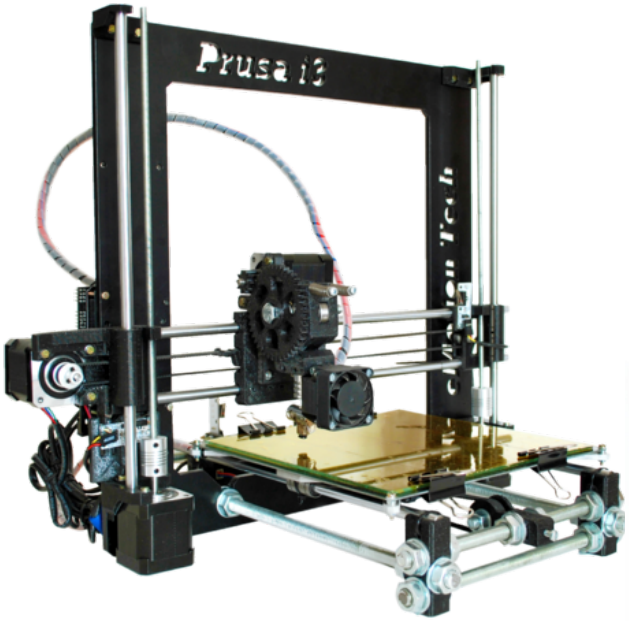
DW Hutmacher et al., Trends in Biotechnology, 22(7): 354 – 362, 2004

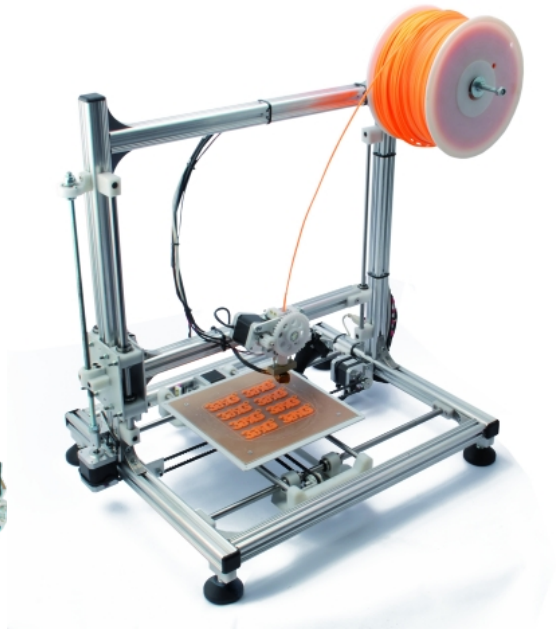


Open source FDM machine: RepRap Project

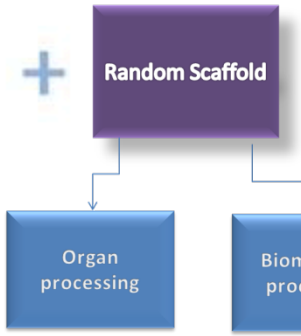
- RepRap is first general-purpose self-replicating manufacturing machine.
- An open source project with several forks

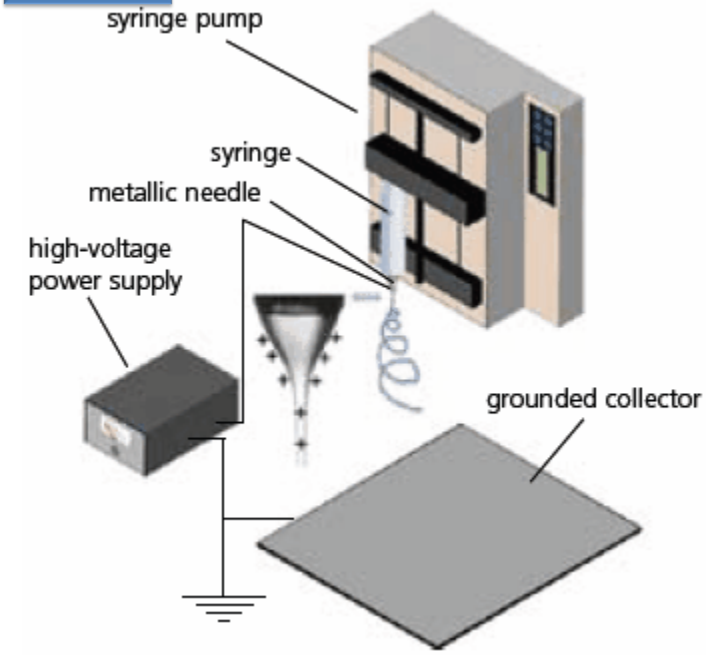


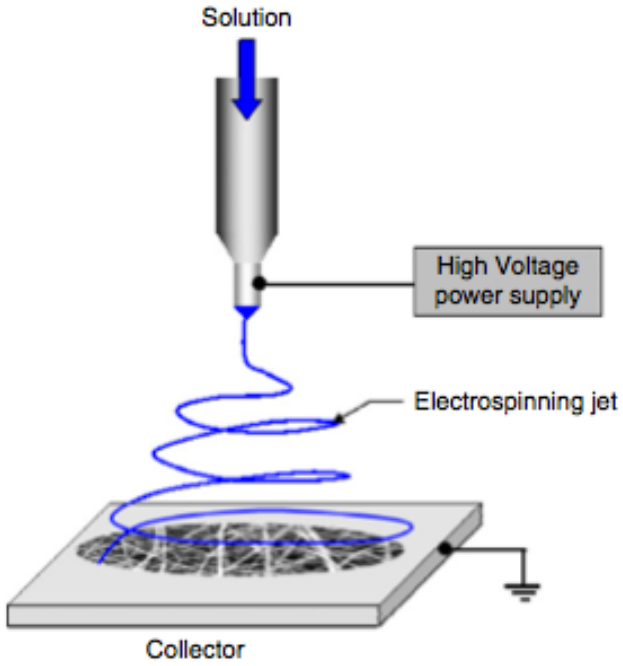


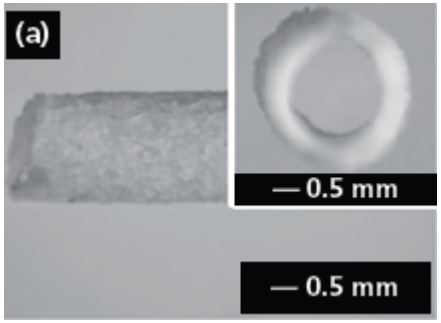


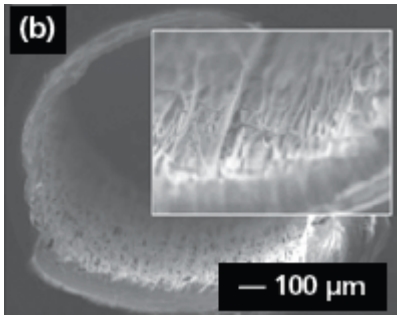
Electrospinning





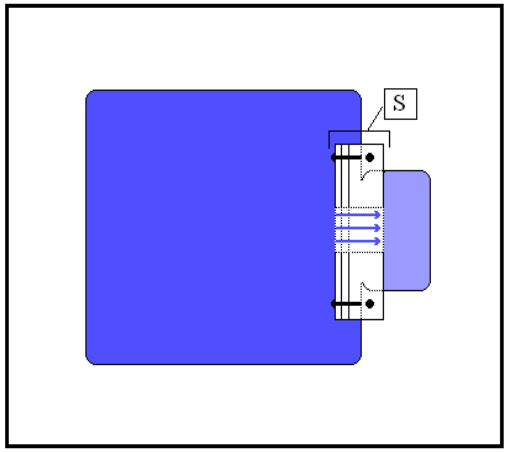


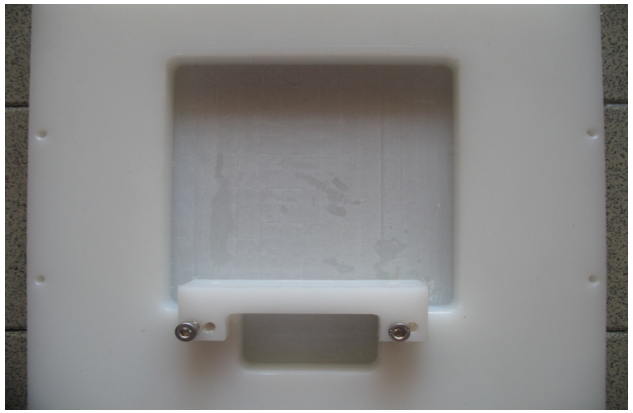


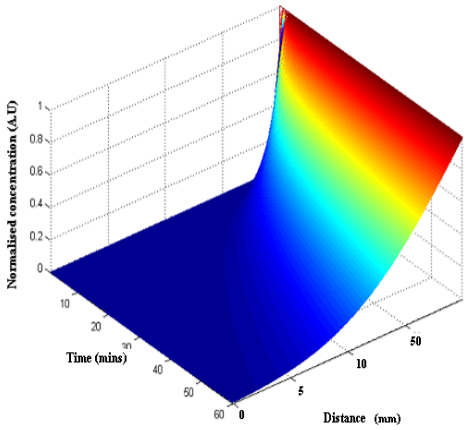


Price?
Materials?
Speed?
Repeatibility ?

Chemical Gradient Concentration

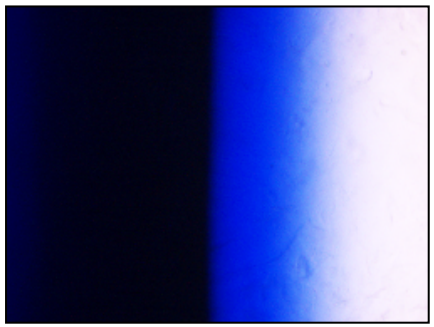




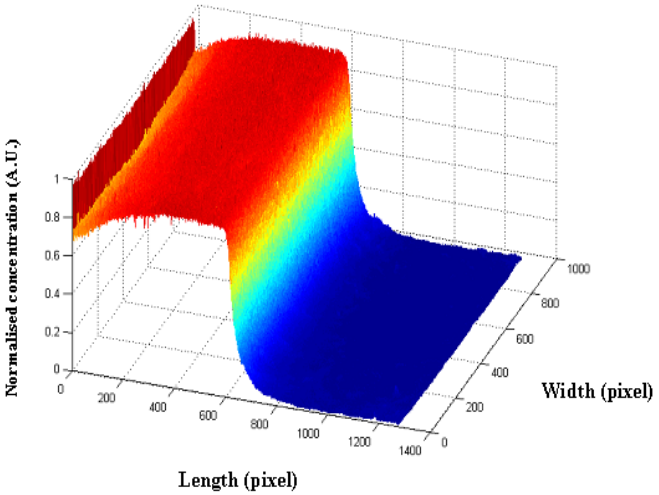


Vozzi G. et al, Mol Biotechnol. 2012 Feb;50(2):99-107.

Chemical Gradient Concentration

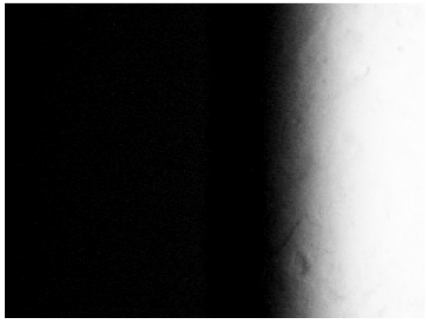


100 µm

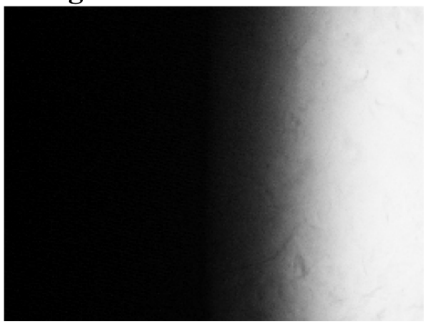


(b)

red channel



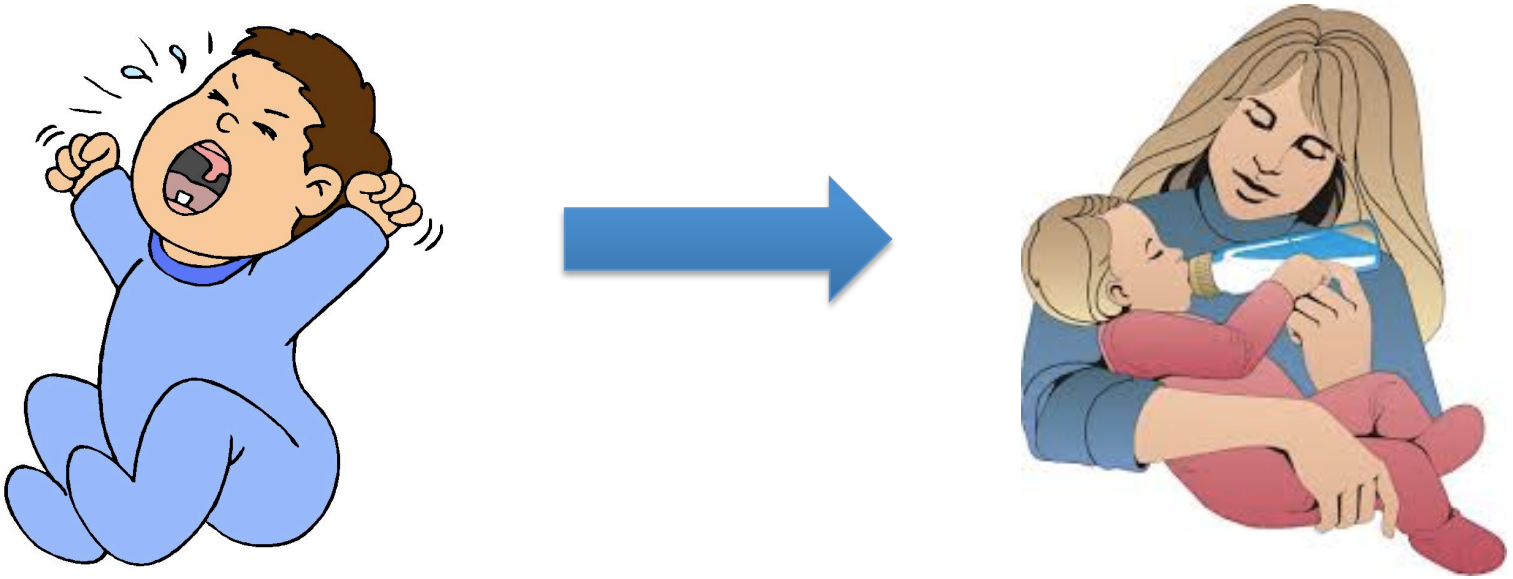
green channel



blue channel

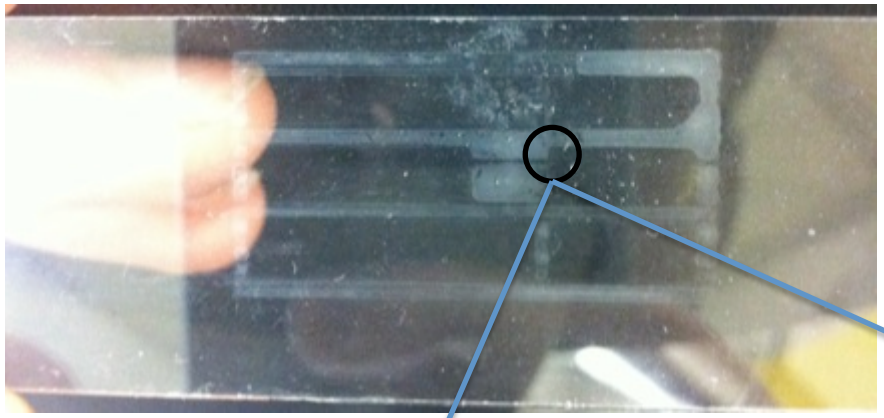
Verso la biologia 3.0?

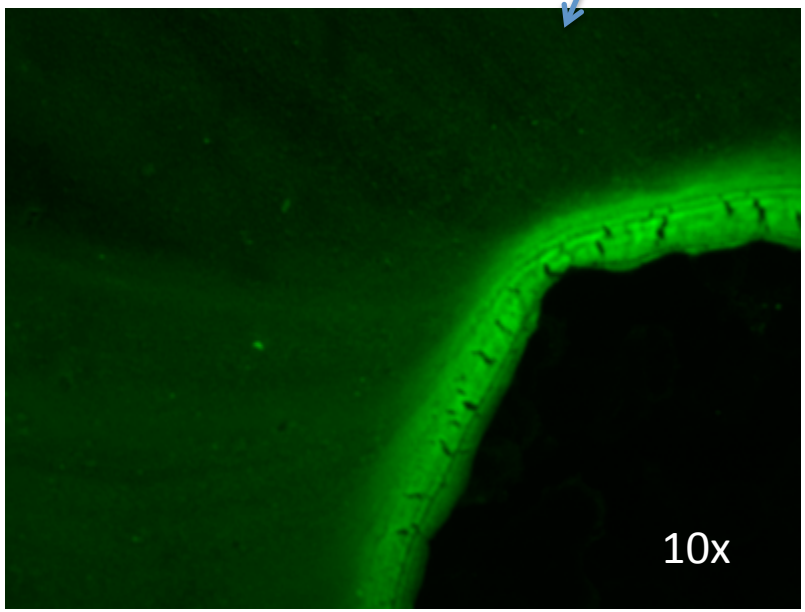
Aggiungere un mezzo di comunicazione
tra il ricercatore e le cellule seminate sullo scaffold

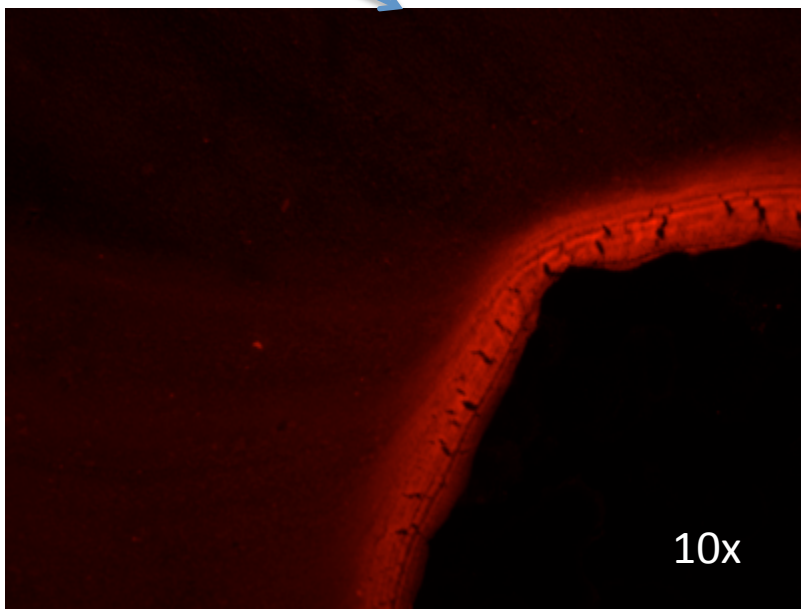


Cell-Human Interactive scaffold (CHIs)

Scaffold sensorizzati

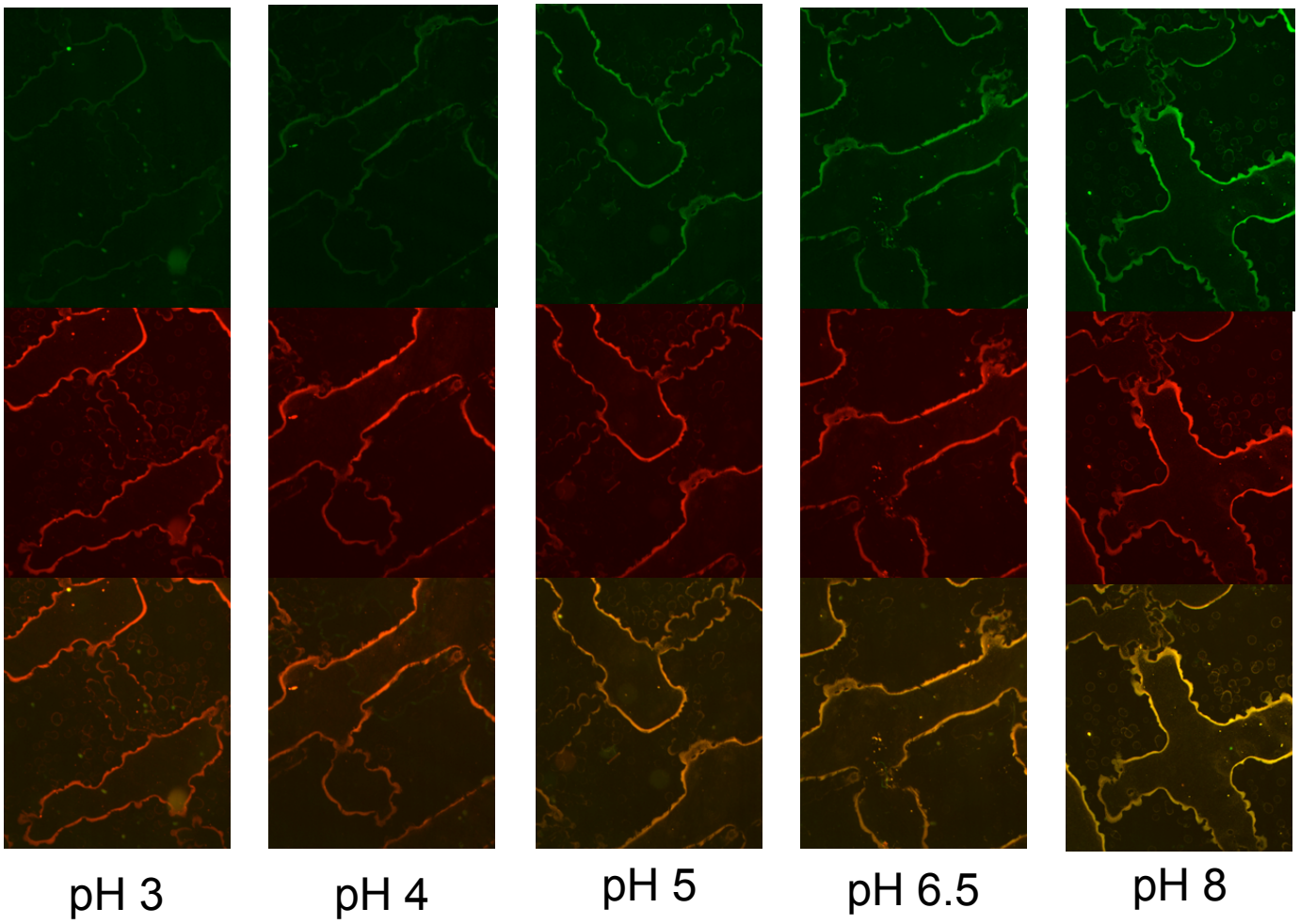




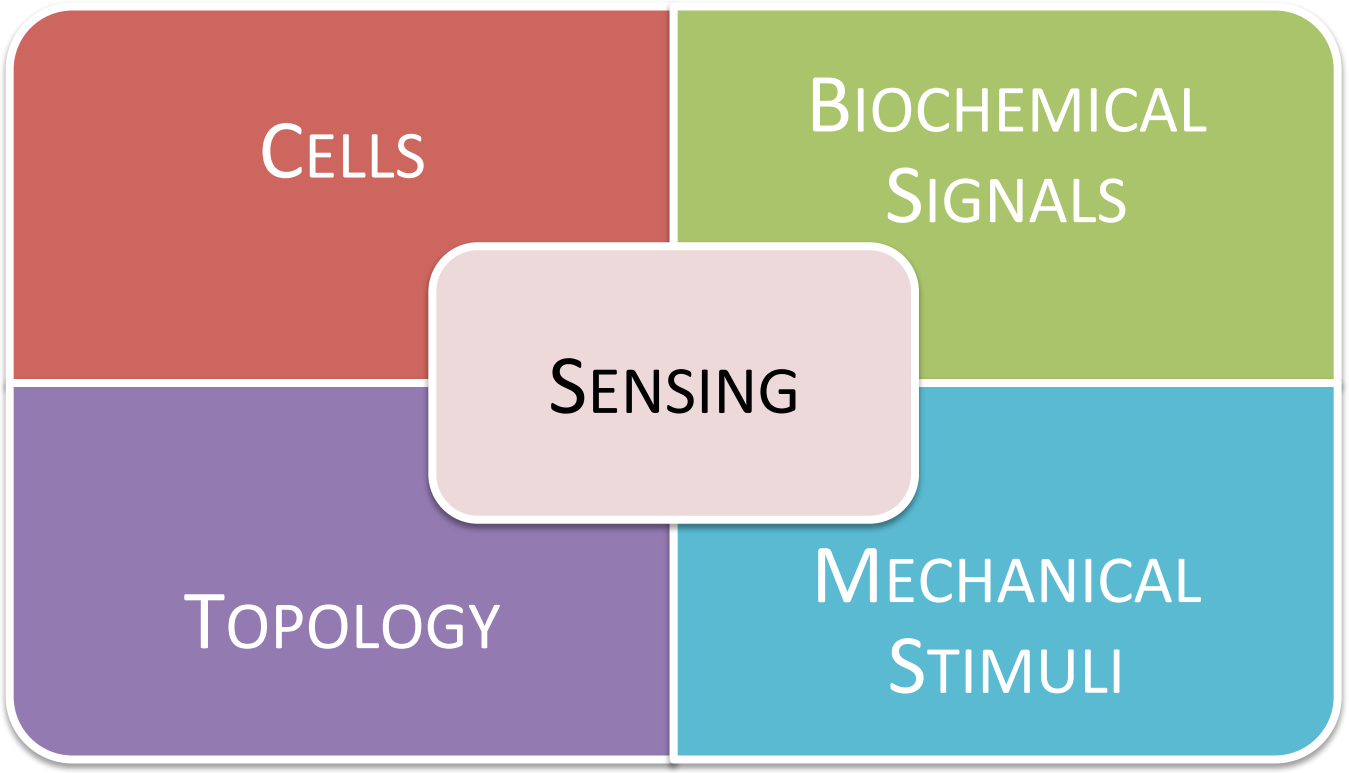


Comunicazione tra le cellule seminate sullo scaffold e il ricercatore

Scaffold sensorizzati



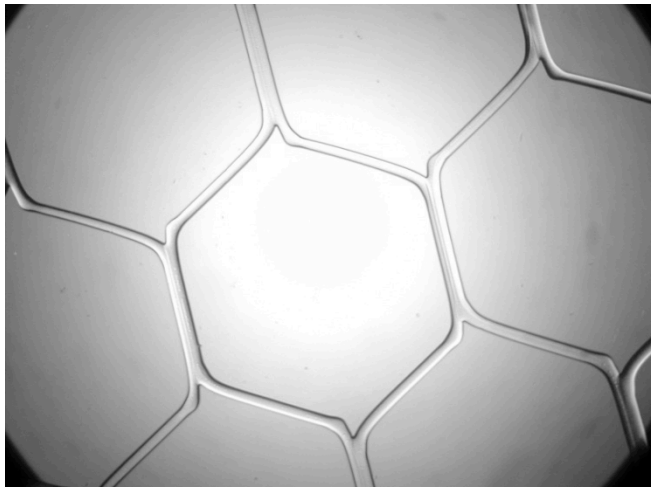
Cell-Human Interactive scaffold



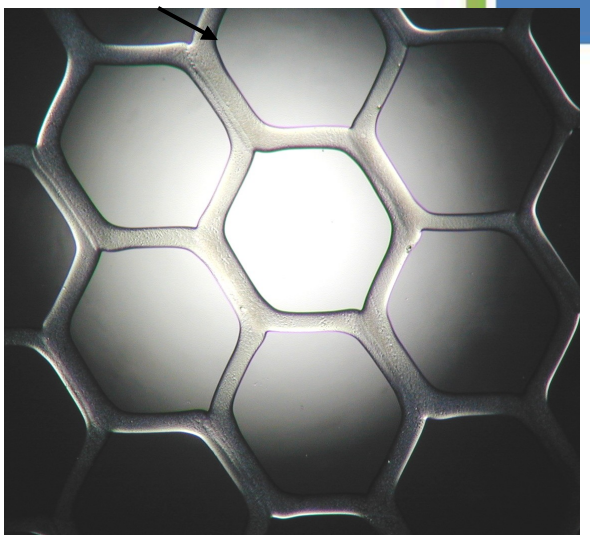
Is Topology important for cell functions?

Topological Stimulus: Neural Tissue

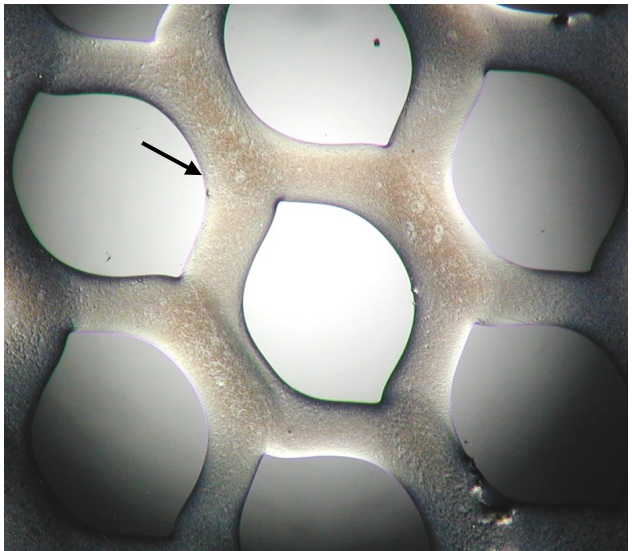
Hexagonal grids with different line width and line length



5 μm

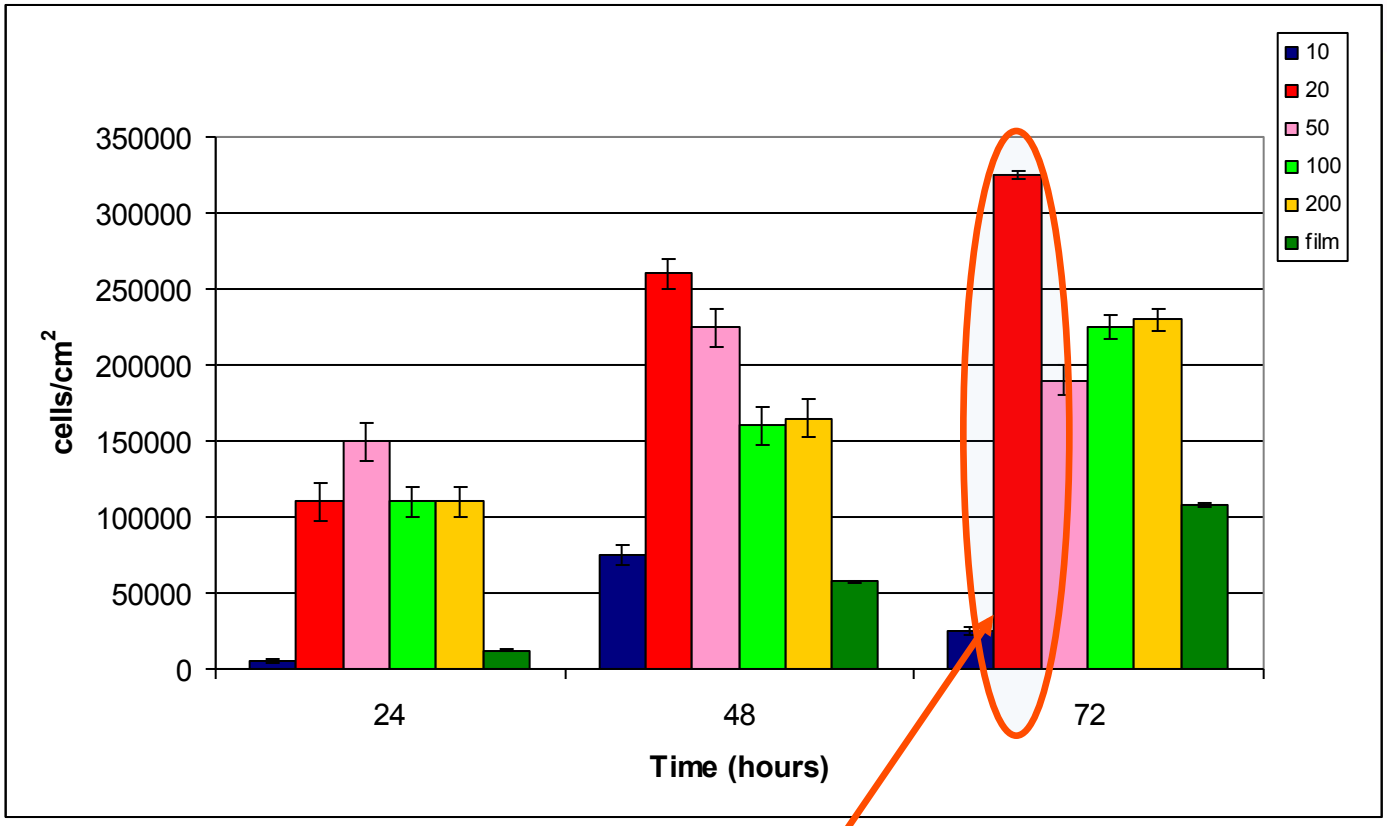


10 μm



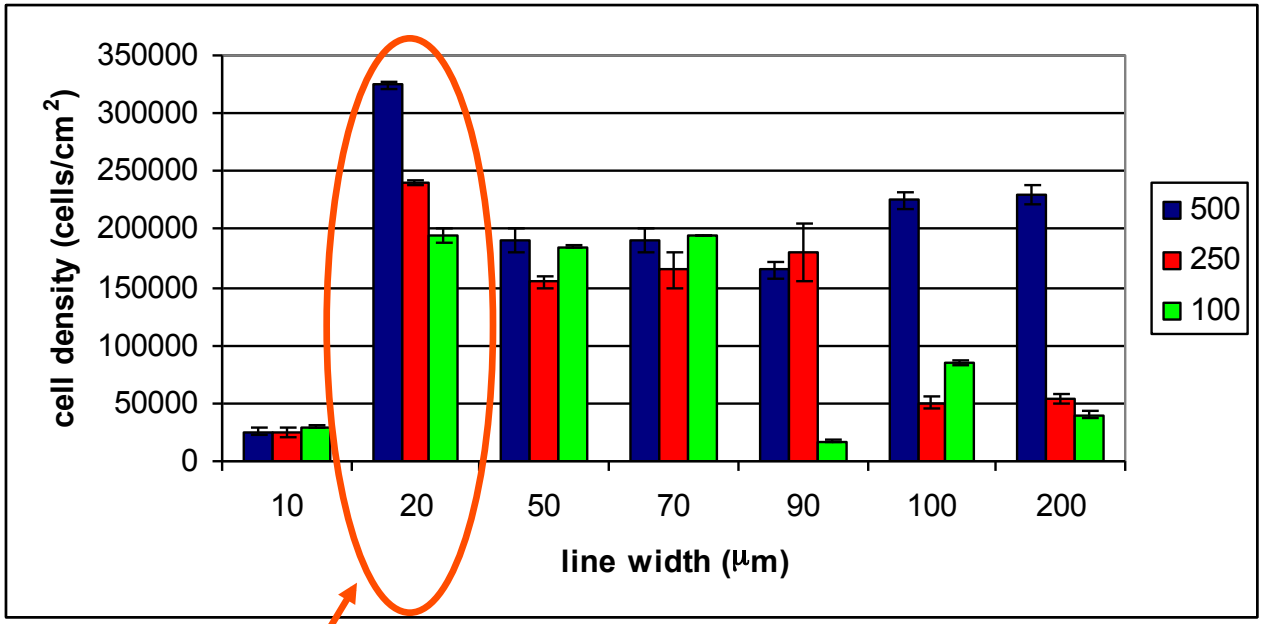
30 μm

Neuronal cells on PAM scaffolds



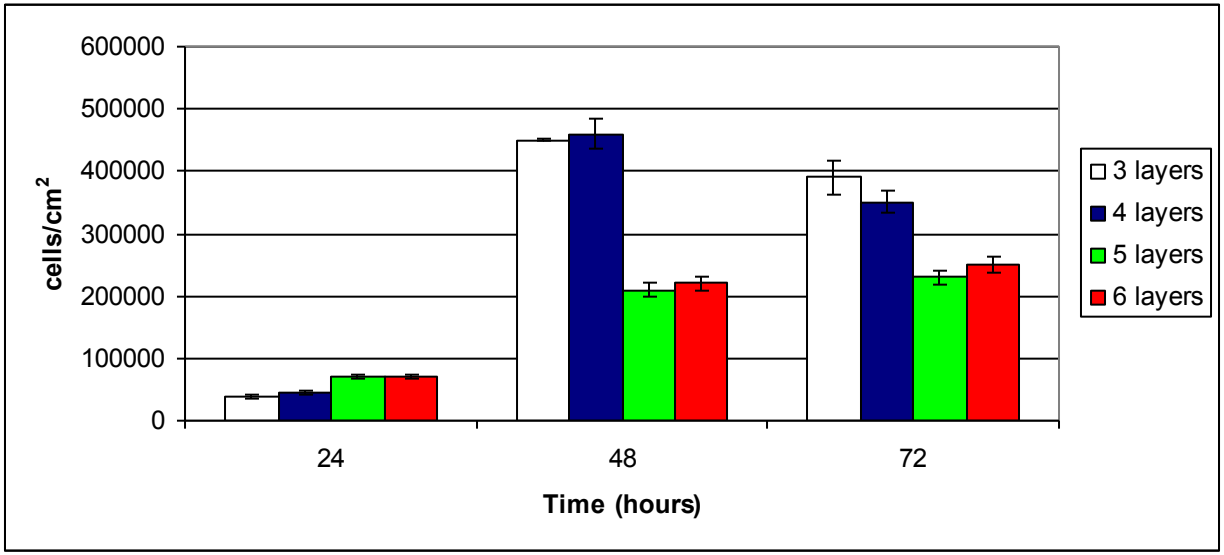
Cell dimension

72h at different line length



Cell dimension

Neuronal cells on 3D PAM scaffold



Increasing layer number nutrient dffusion is limited

Kullenberg J. et al, Tissue Eng Part A. 2008