3D PRINTED SMART OBJECTS: A PROOF OF CONCEPT

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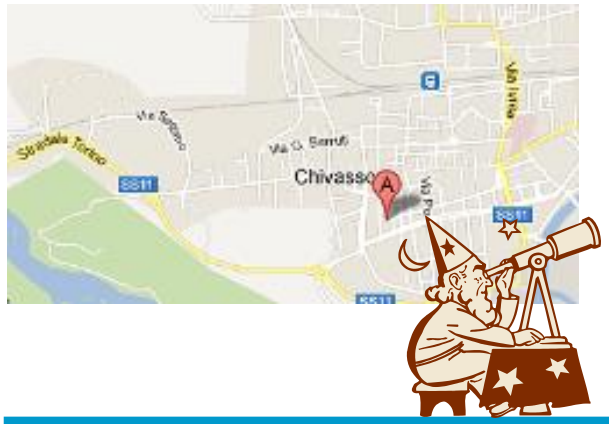
Conference & Exhibition

χ-LAB Materials and Microsystems Lab



Mission

- fundamental research on materials and processes for micro- and nano-technologies
- design and fabrication of 3D prototypes, MEMS, nanostructures, LOC, etc.
- education

Staff

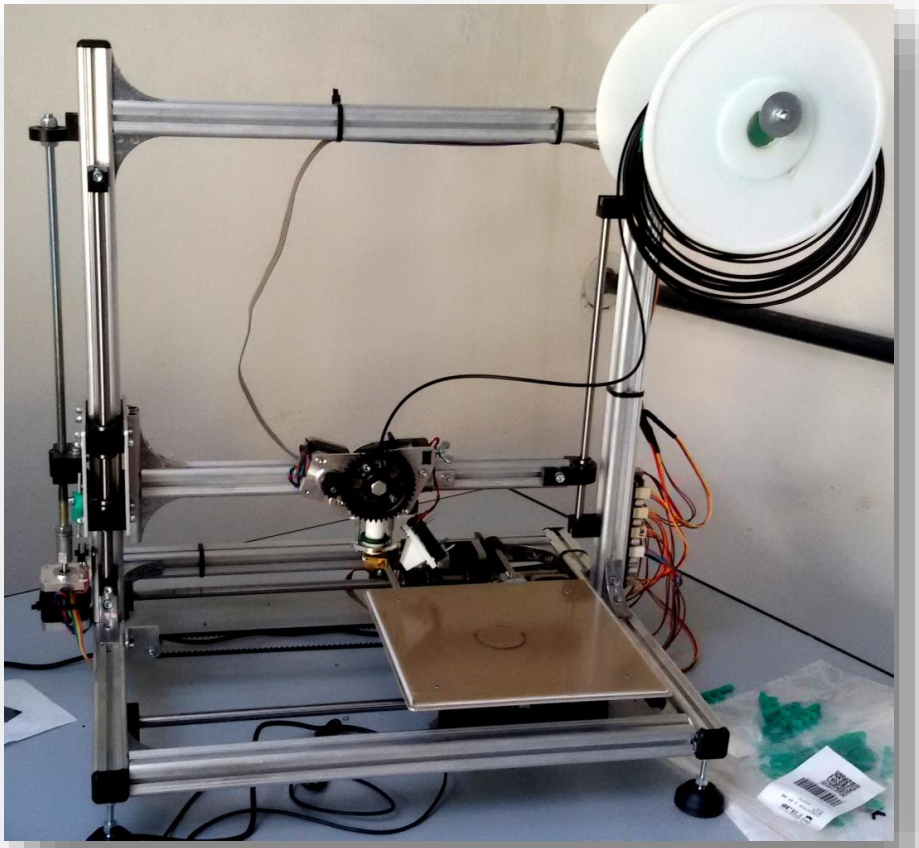
- 5 Professors
- 8 Researchers
- 16 Fellowships / Post Doc
- 8 PhD students
- 3 Technicians
- 2 Administratives

3D PRINTERS

- **Velleman – K8200 *FDM*** The plastic filament is channeled inside of an extruder and, from this, it is transferred to a heated nozzle which brings the material to the melting temperature and releases it to the semi-fluid state on the work surface

Very low cost material.
High temperature thermoplastic

Resolution:
500 µm (X and Y axis)
Layer Thickness: 150 µm



3D PRINTER K8200

3D PRINTERS

- **Objet30**

The printer uses the PolyJet technology: drops of liquid photopolymers are deposited and polymerized through UV rays. The thin layers, one on top of the other, create the 3D model. The printer also deposits **support material** which can be removed manually or with a hydrojet system.

Surface finishing:
Glossy or Matte.

Resolution:
600 dpi (X and Y axis)
900 dpi (Z axis)
Layer Thickness: 28 µm

3D PRINTERS

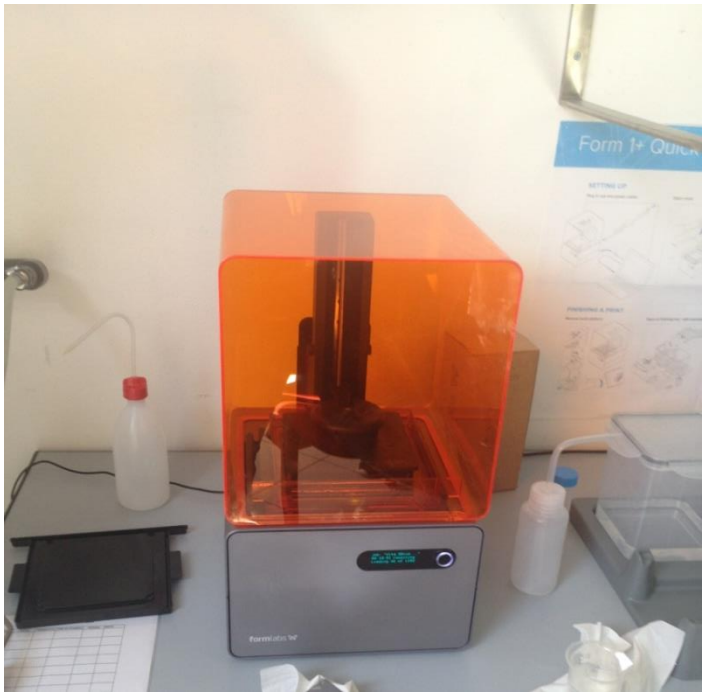
- **Formlabs Form 1+**

It uses the Stereolithography (SLA) technology. The platform goes towards the tank below containing resin, which is hardened (layer by layer) by the laser. The platform moves upward until the piece is complete. It also prints an adequate **support structure**.

Low cost high resolution material.

Resolution
(Nominal Minimum feature size): 250 µm
Layer Thickness: 25-200 µm

formlabs



3D PRINTERS

- **Sharebot SnowWhite**

Based on the DLS (Direct Laser Sintering) technology. The printer creates 3D objects through laser sintering of thermoplastic powder, one layer at a time. No support material is necessary and therefore there is no removal process.

Thermoplastic
No support needed

Minimum Layer Thickness:0.04mm

SHAREBOT

PRINTING OF SMART OBJECTS

- 3D printing is a breakthrough technology successfully employed in different engineering fields
- 3D additive manufacturing is a freeform, low cost and an easy access bottom up technology
- Low cost materials and processes are used to pass easily from the idea to the fabrication

PRINTING OF SMART OBJECTS

- Is this technology ready to produce active smart objects?
- How can sensors and actuators be embedded in 3D printed parts?
- Is it possible to obtain electronic devices using this technology?

THE ROLE OF MATERIAL

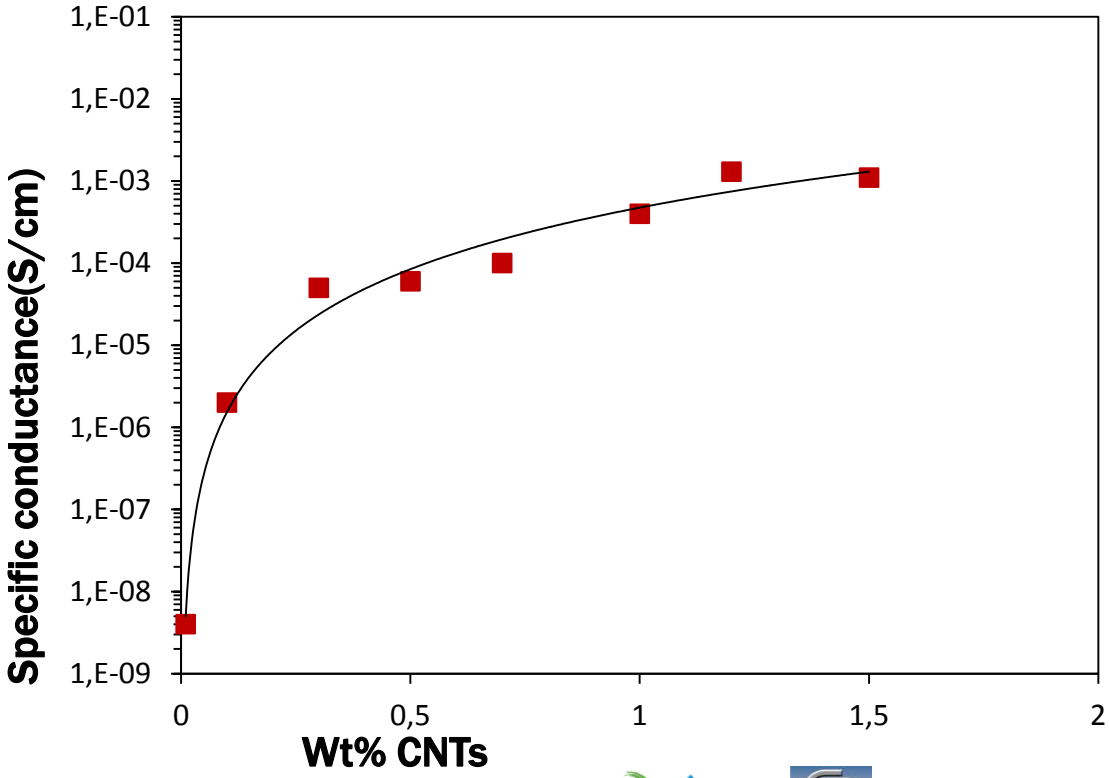
- to obtain an actual 3D smart object new materials should be employed

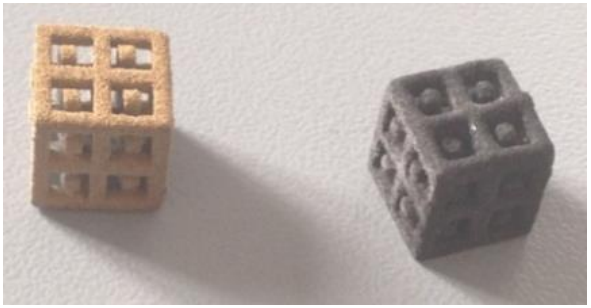
COMMERCIAL Composite PLA
Electrically Conductive Graphite
is available to be used as conductive 3D printing material for FFD

THE ROLE OF MATERIAL

- to obtain an actual 3D smart object the research on new functional material is fundamental

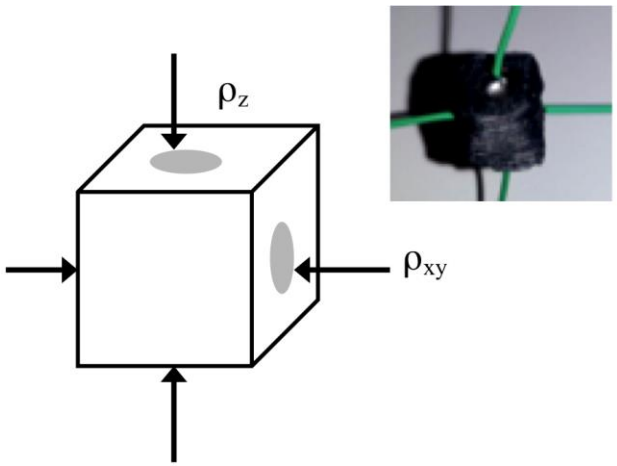
SW-CNT and GRAPHENE BASED Composites
are under investigations





MATERIAL CHARACTERIZATION

- commercial PLA composite was used as benchmark for our study



Resistivity along z axis
Resistivity along x,y plane

$$\rho = \frac{R \cdot S}{L}$$

$\rho_{x,y}$ 5.6 Ω·cm

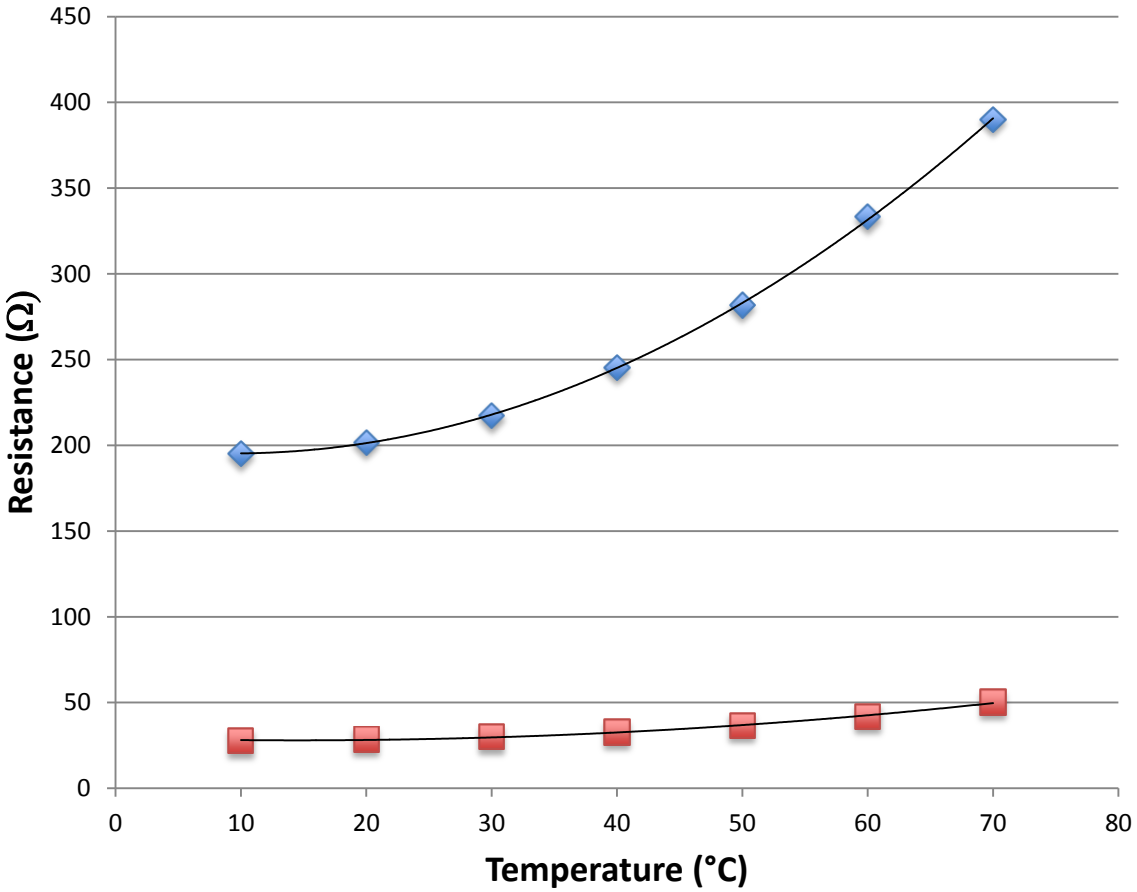
ρ_z 39.5 Ω·cm

Temperature (°C)	$R_{x,y}$ (Ω)	ρ_{xy} (Ω·cm)
10	27.66	5.42
20	28.64	5.61
30	29.97	5.87
40	32.72	6.41
50	36.56	7.16
60	41.81	8.20
70	50.28	9.86

Temperature (°C)	R_z (Ω)	ρ_z (Ω·cm)
10	195.23	38.26
20	201.77	39.55
30	217.33	42.60
40	245.46	48.11
50	281.87	55.25
60	333.33	65.33
70	389.99	76.44

MATERIAL CHARACTERIZATION

- experimental results of resistance as a function of temperature



Polynomial model

$R_z(T) = 0{,}0532\ T^2 - 0{,}9\ T + 199$

$R_{x,y}(T) = 0{,}0071 T^2 - 0{,}2\ T + 29$

3D PRINTED SMART CAP

- fabrication of a smart object to monitor the temperature and the status in a bottle cap

PolyJet technology

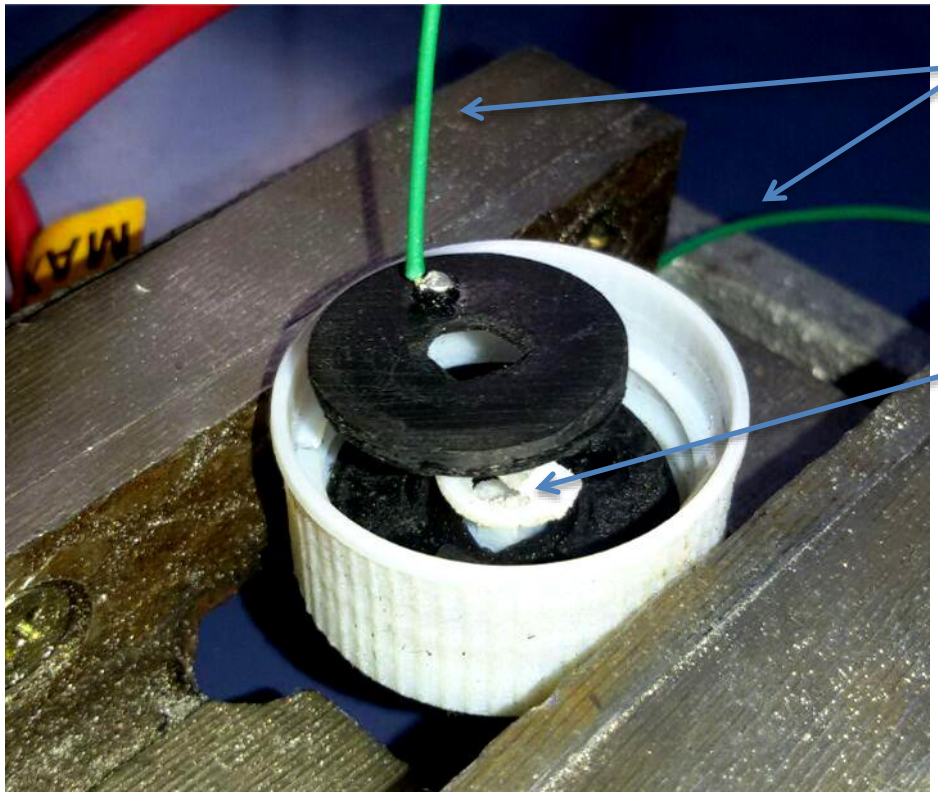
FDM technology

3D PRINTED SMART CAP

- ***VeroWhite***: PolyJet Technology – Material
  - mechanical function, long term durability, high resolution, good flexibility (complex part need high accuracy and good reproducibility, i.e. spring).
- ***PLA conductive***: FDM Technology - Material
  - The polylactic acid (PLA) carbon based composite to obtain electrical contact and sensing

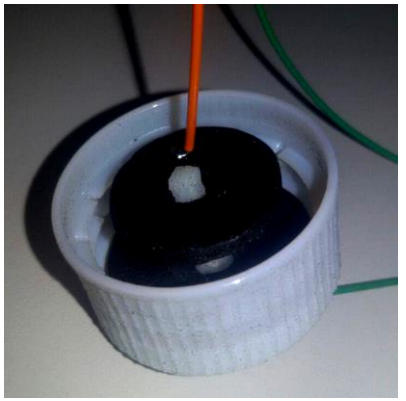
3D PRINTED SMART CAP

- 3D printed prototype

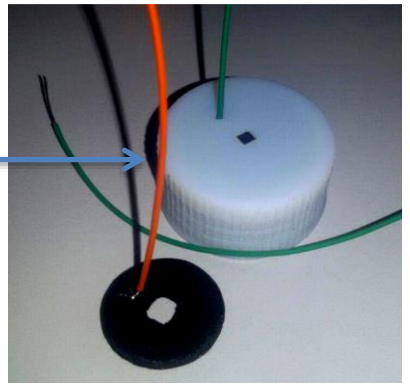


wires

spring

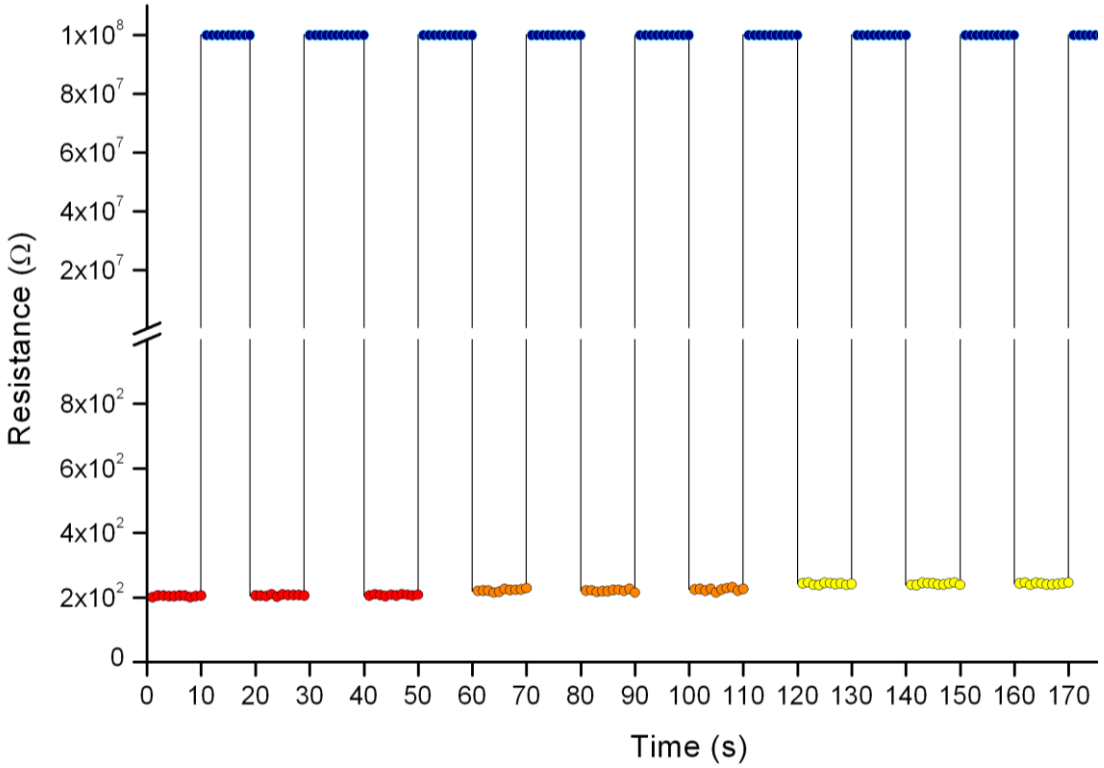


cap



3D PRINTED SMART CAP

- Open / close characterization and temperature sensing



CONCLUSION

- 3D printing of smart objects is possible
- it depends strictly by the functionality introduced by the materials
- Polymer composites are eligible candidates as functional materials
- Polymer composites should be carefully characterize to find all their intrinsic properties

Thank you for your attention !

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