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Confindustria Milano Monza e Brianza



POLITECNICO
MILANO 1863

3D PRINTING HIGH PERFORMANCE MATERIALS

Continuous Fiber Composites Smart Manufacturing Process

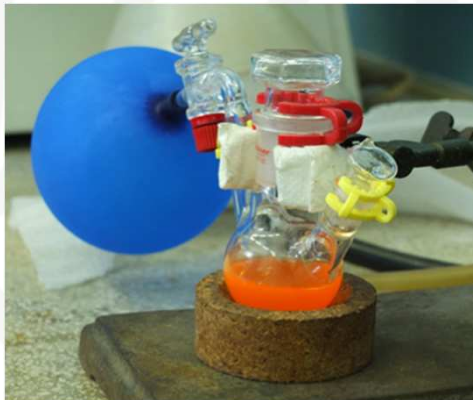
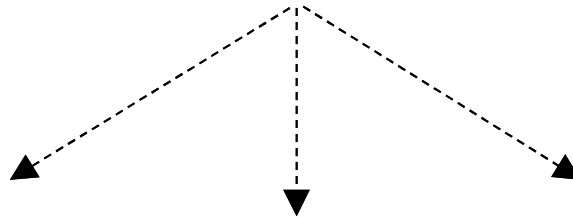
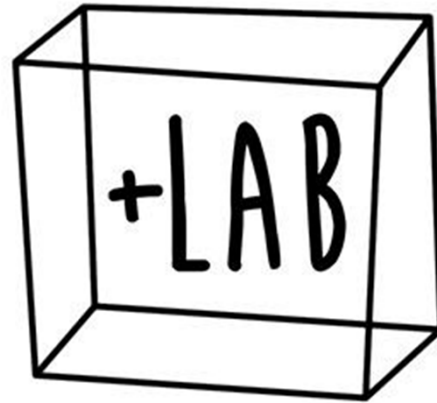
Speaker

Marinella Levi, Gabriele Natale

6 luglio 2016



+LAB: la ricerca sulla stampa 3D



Materiali



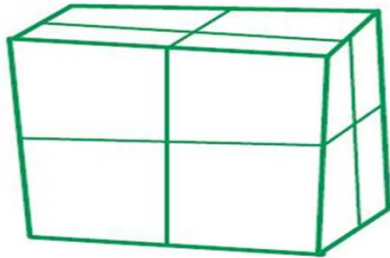
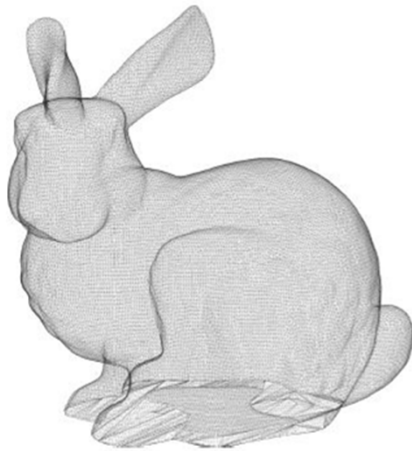
Applicazioni



Processi

la stampa 3D

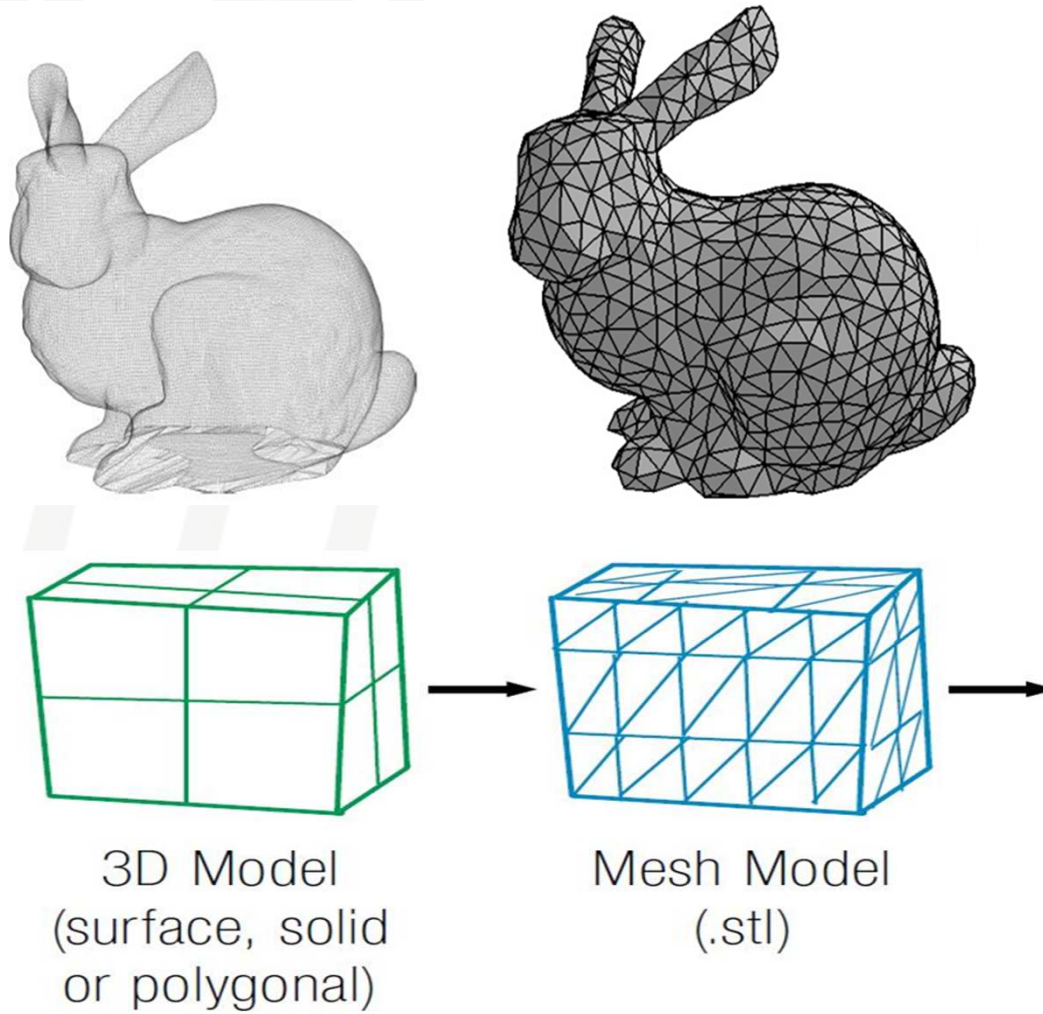
dal CAD alla macchina CNC layer by layer



3D Model
(surface, solid
or polygonal)

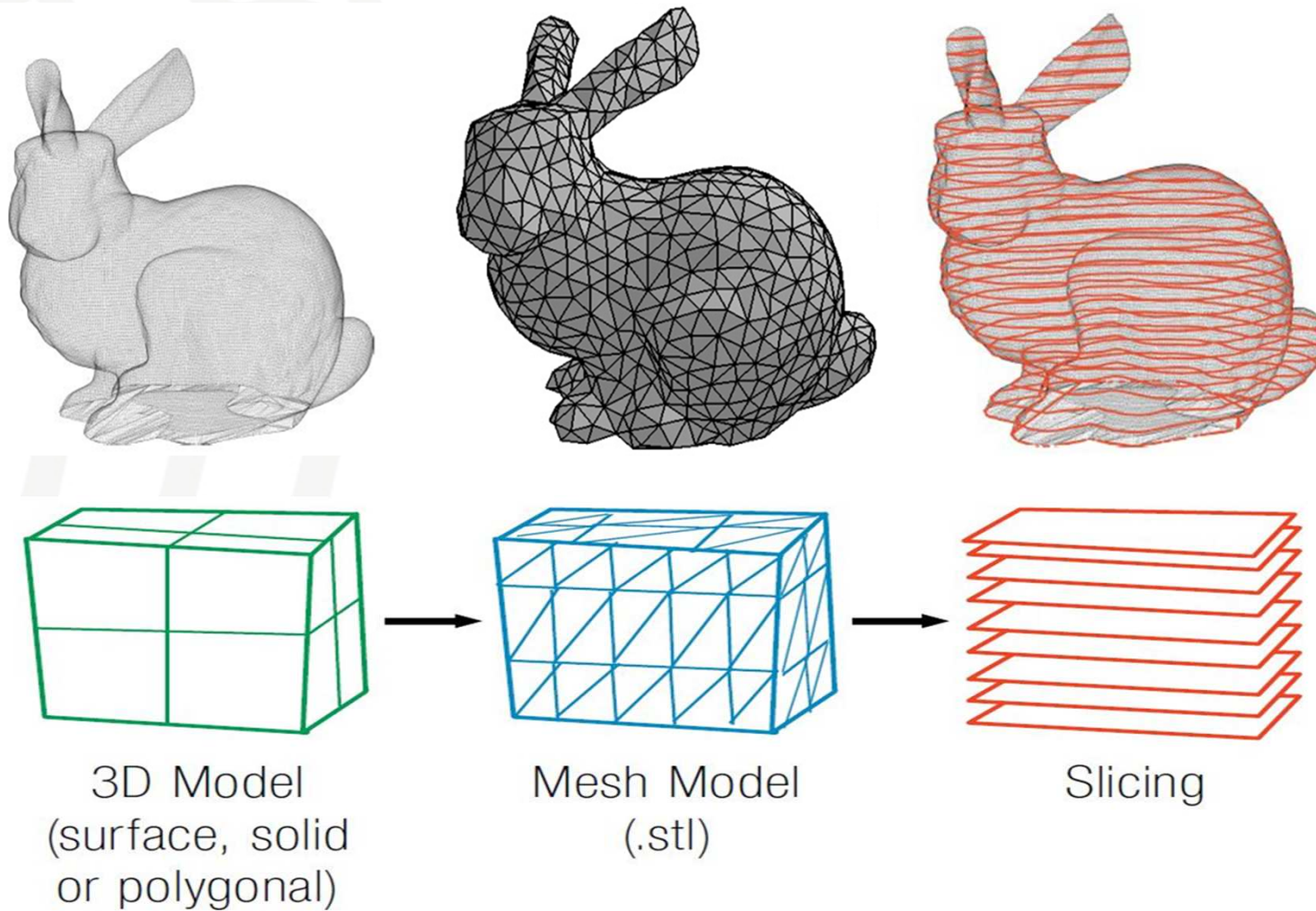
la stampa 3D

dal CAD alla macchina CNC layer by layer

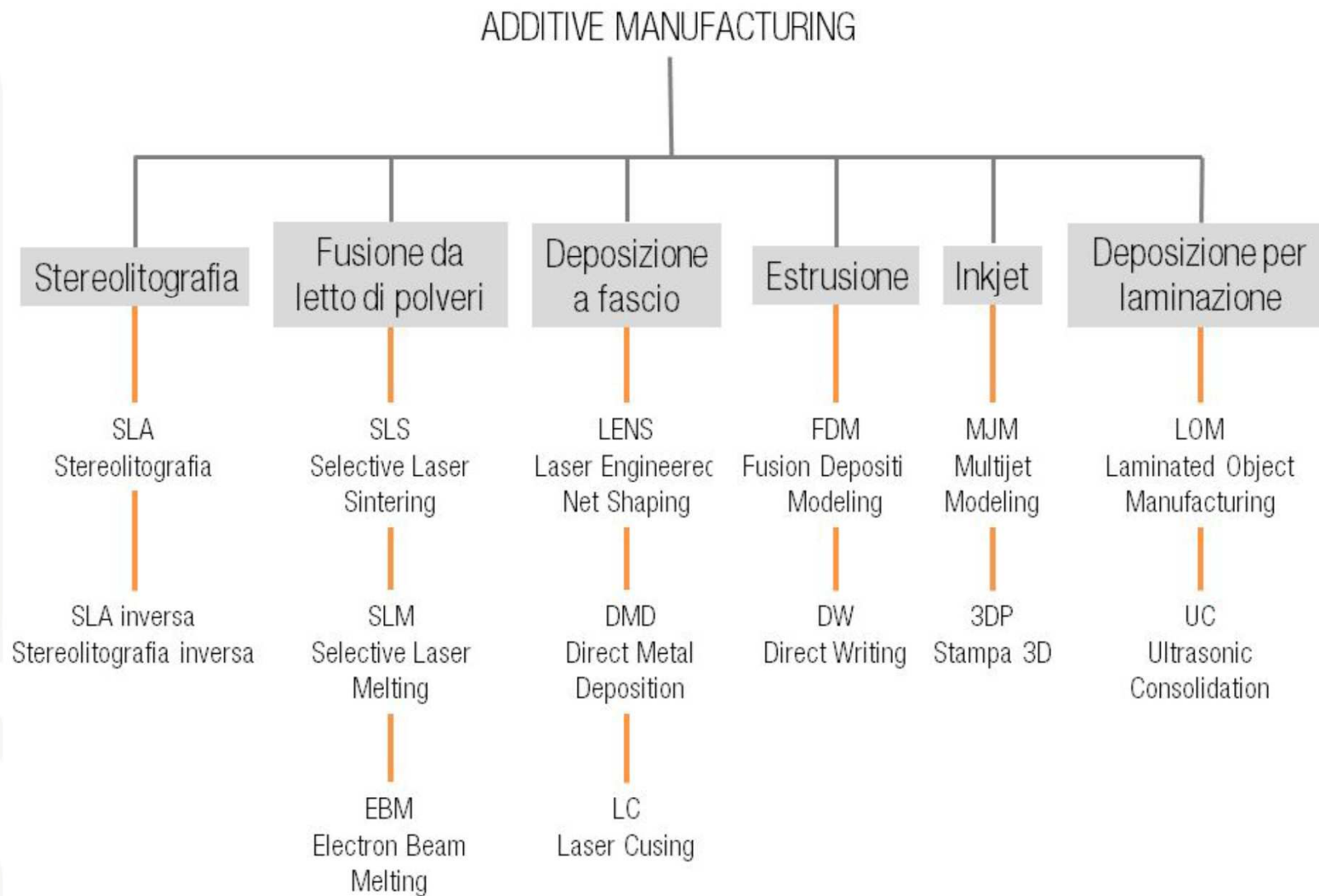


la stampa 3D

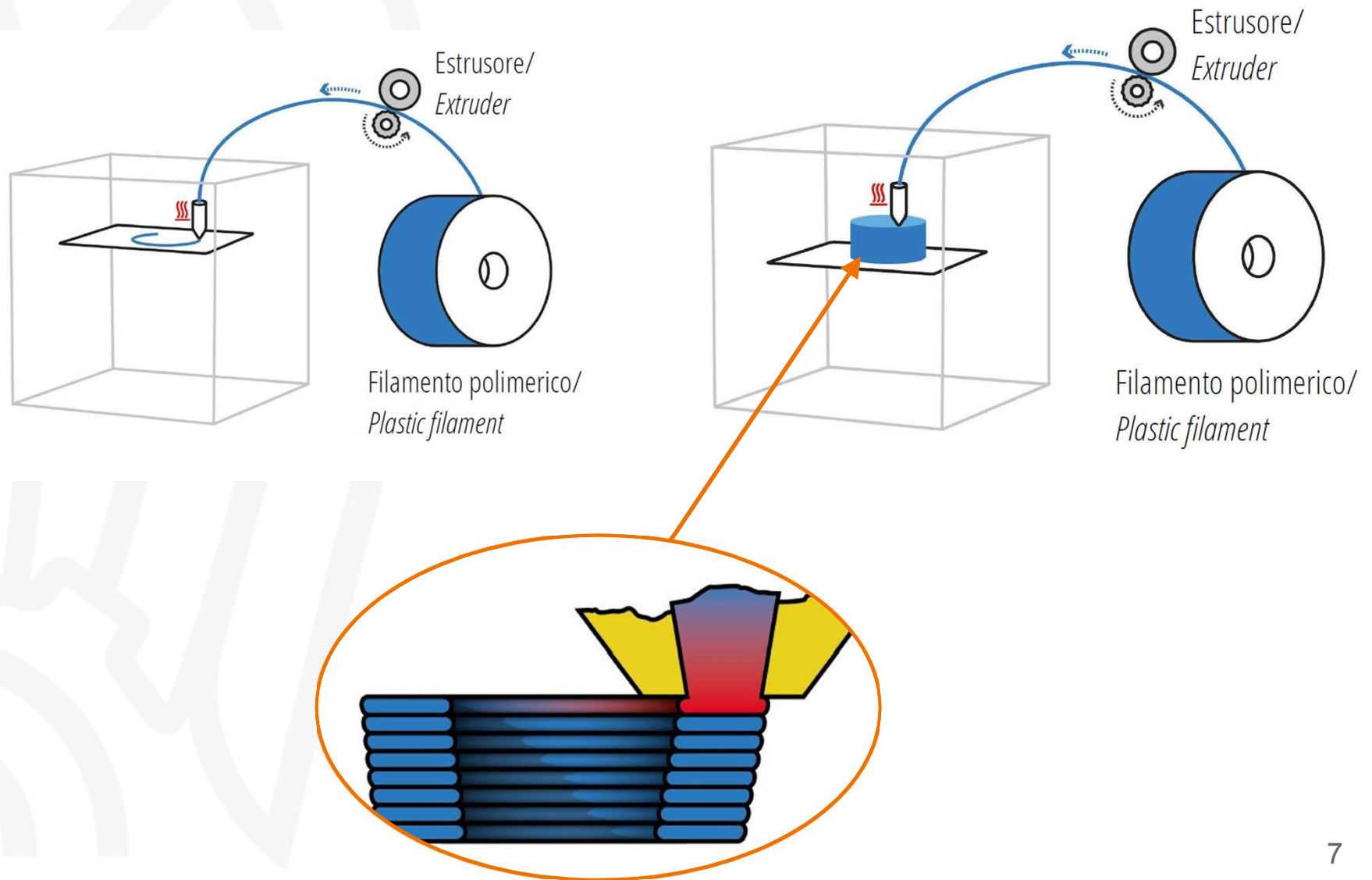
dal CAD alla macchina CNC layer by layer



Le tecnologie



layer by layer process



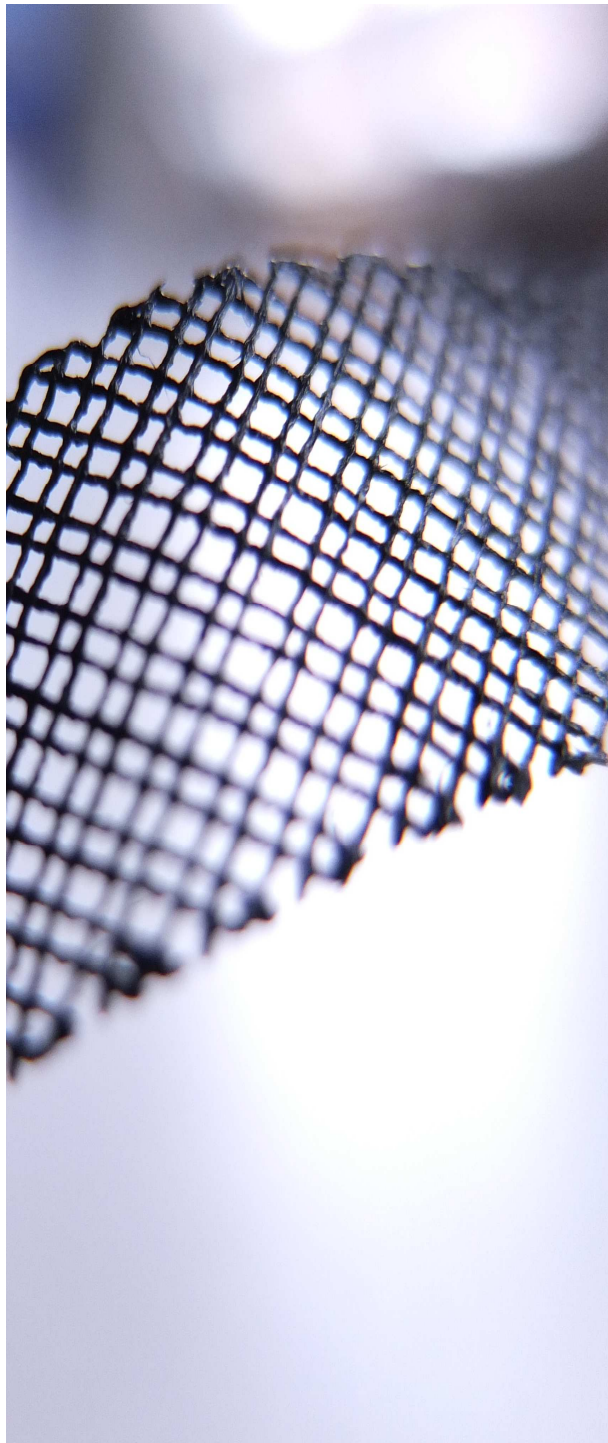


l'idea

idea

La **stampa 3D** produce **oggetti *anisotropi***.
I **materiali compositi** sono ***anisotropi***.

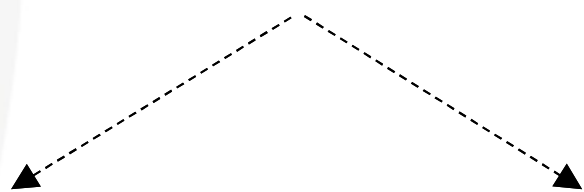
**E' possibile combinare insieme materiali
compositi e tecnologia additiva?**



le 3 linee di ricerca

L'importanza della matrice

MATERIALI COMPOSITI



```
graph TD; A[MATERIALI COMPOSITI] -.-> B[Matrice Termoplastica]; A -.-> C[Matrice Termoisolante];
```

Matrice Termoplastica

Matrice Termoisolante

L'importanza della matrice

MATERIALI COMPOSITI

Matrice Termoplastica

Matrice Termoindurente

L'importanza della matrice

MATERIALI COMPOSITI

~~Matrice Termoplastica~~

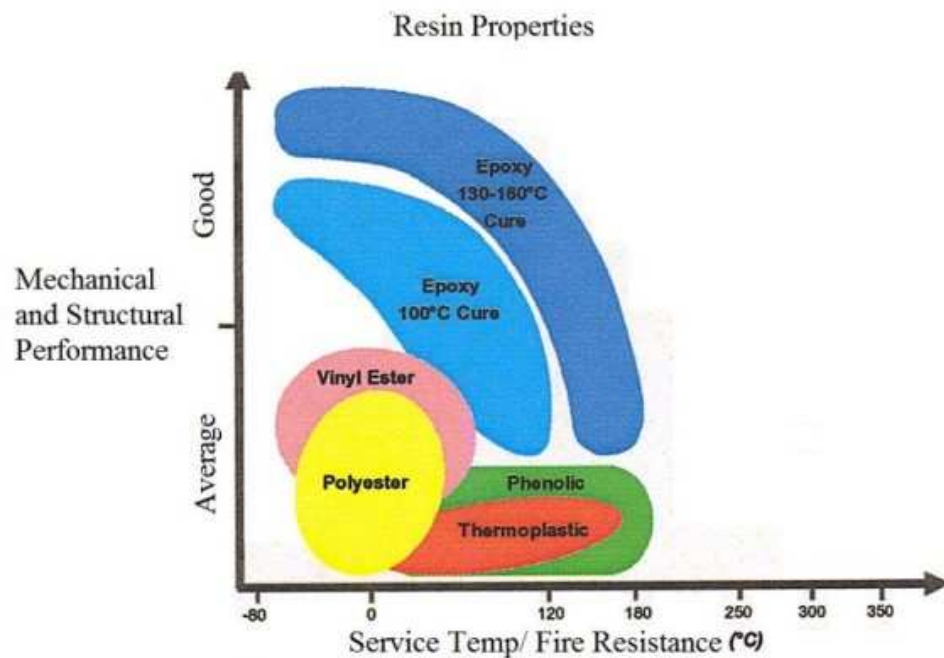
Matrice Termoindurente

L'importanza della matrice

MATERIALI COMPOSITI

Matrice Termoindurente

- Prestazioni meccaniche
- Resistenza chimica
- Temperature di esercizio
- Bassa igroscopicità
- Costo



ORTHOTIC COMPOSITES

L'importanza della matrice

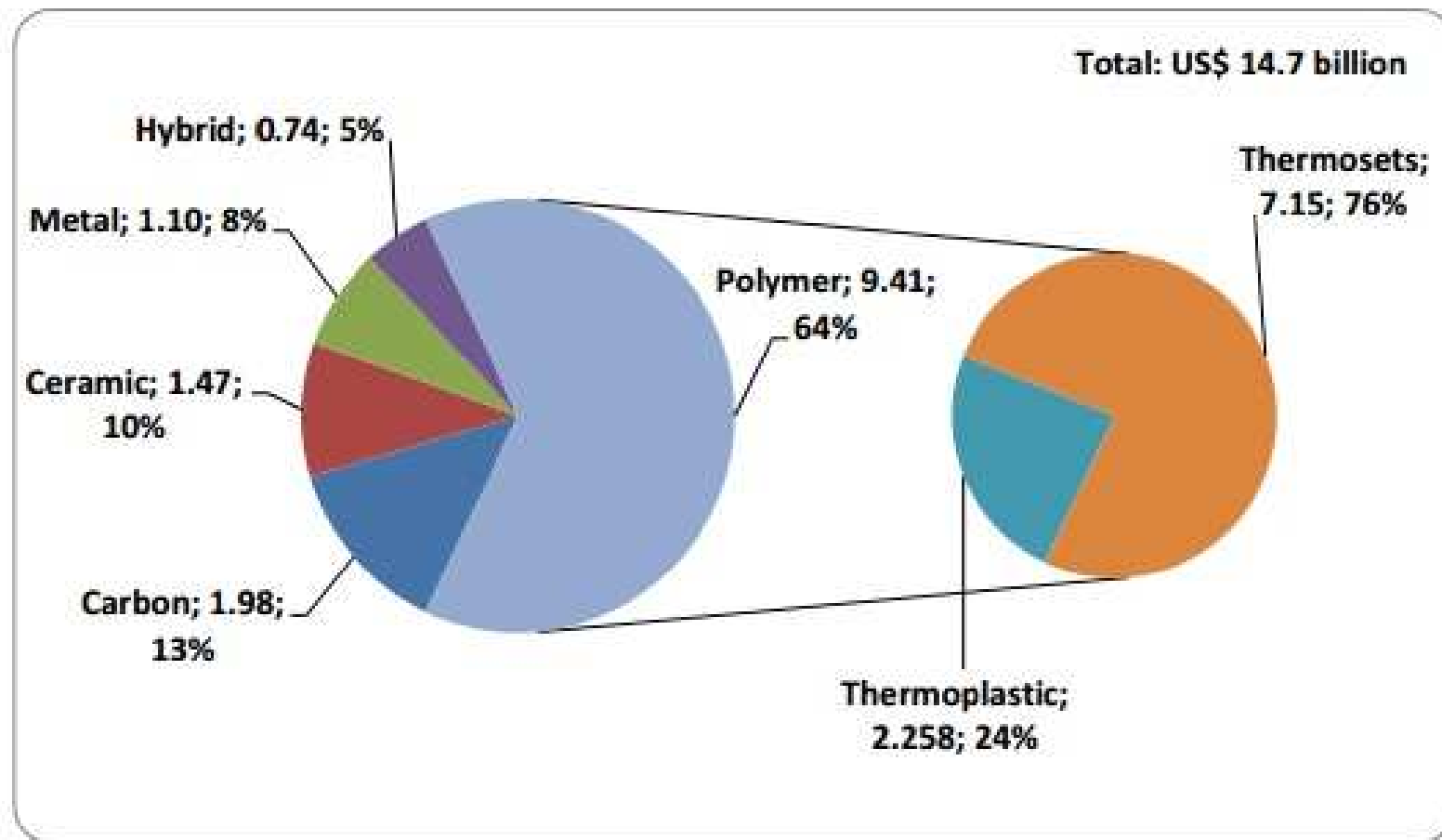
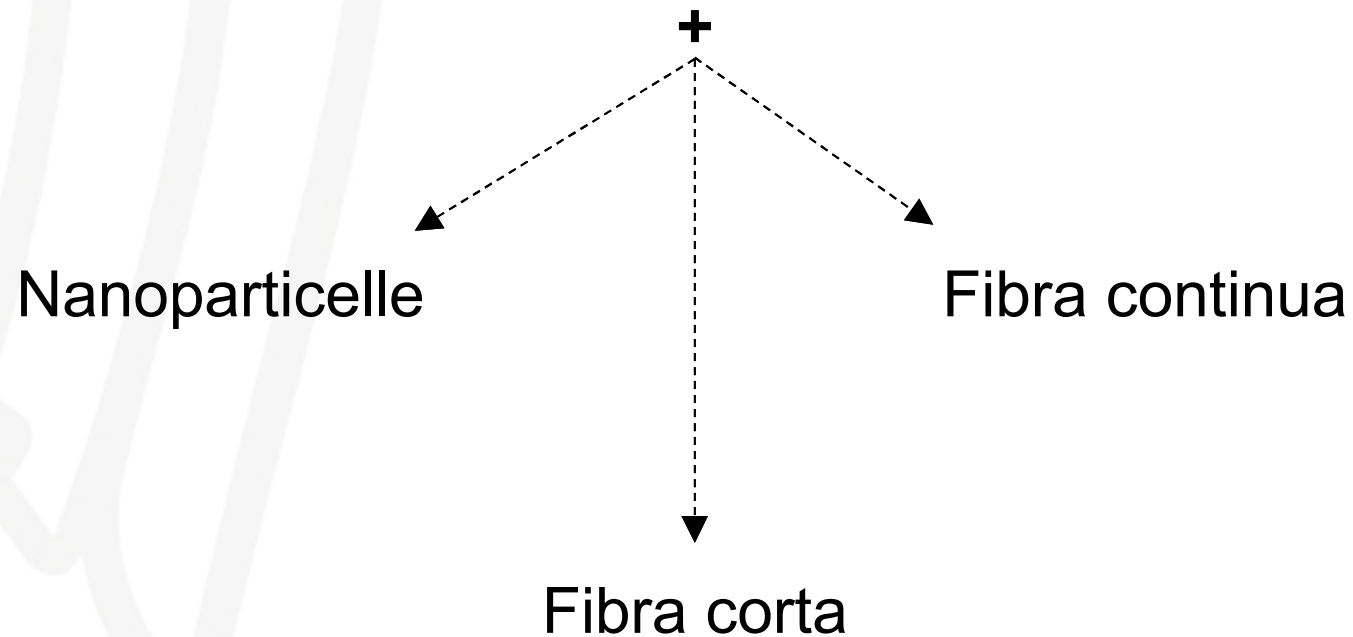


Fig. 7: Carbon composite revenues in US\$ billion by matrix material (2013). [2]

3 linee di ricerca

MATERIALI COMPOSITI a matrice **termoindurente**



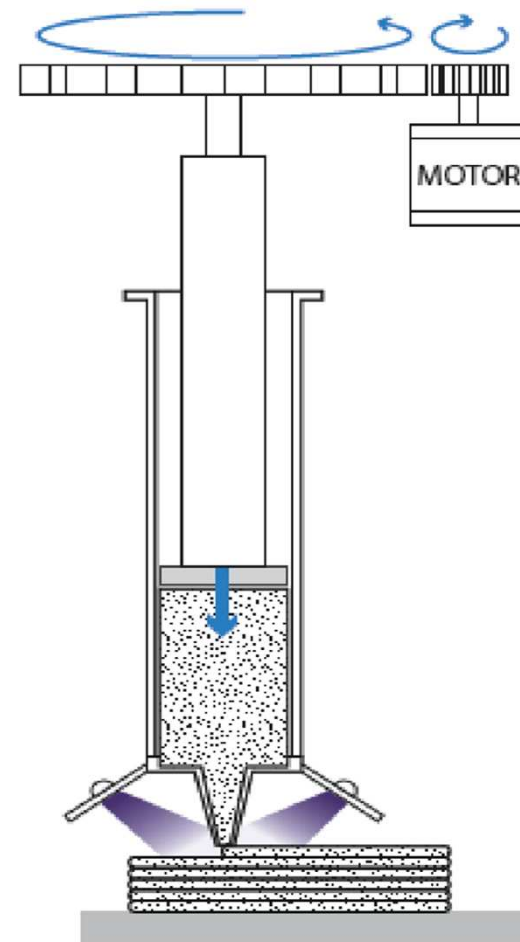
A high-magnification microscopic image showing a dark, textured, hourglass-shaped structure. The structure has a central narrow neck and two wider, flared ends. The surface is highly textured with visible horizontal ridges and a granular appearance. The background is a light, out-of-focus gradient.

compositi a fibra corta e nanocompositi

la tecnologia: sistema LDM

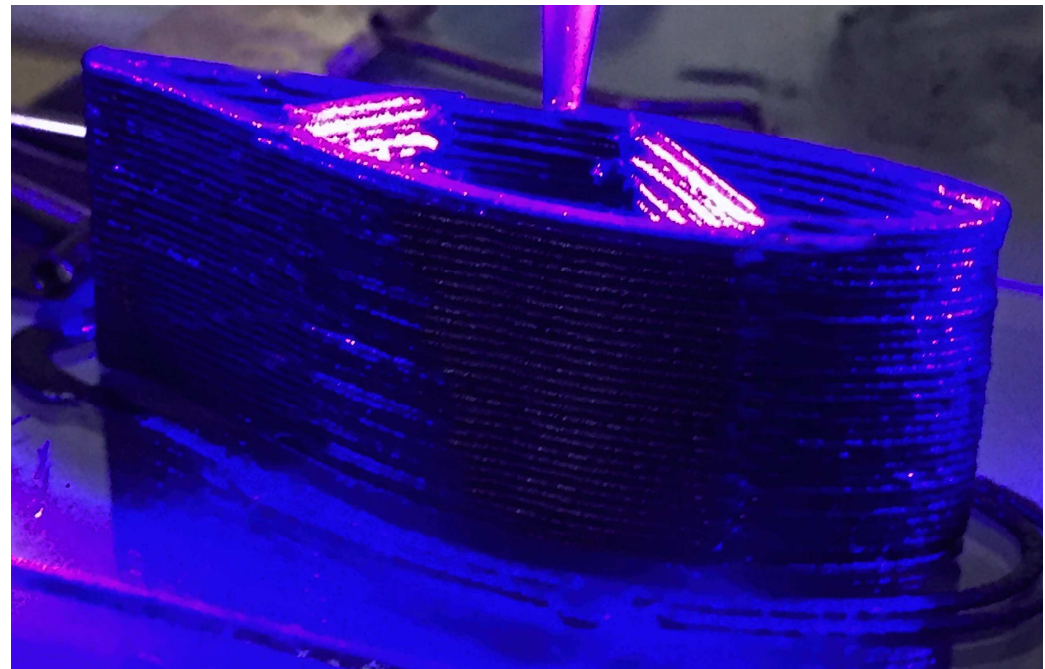
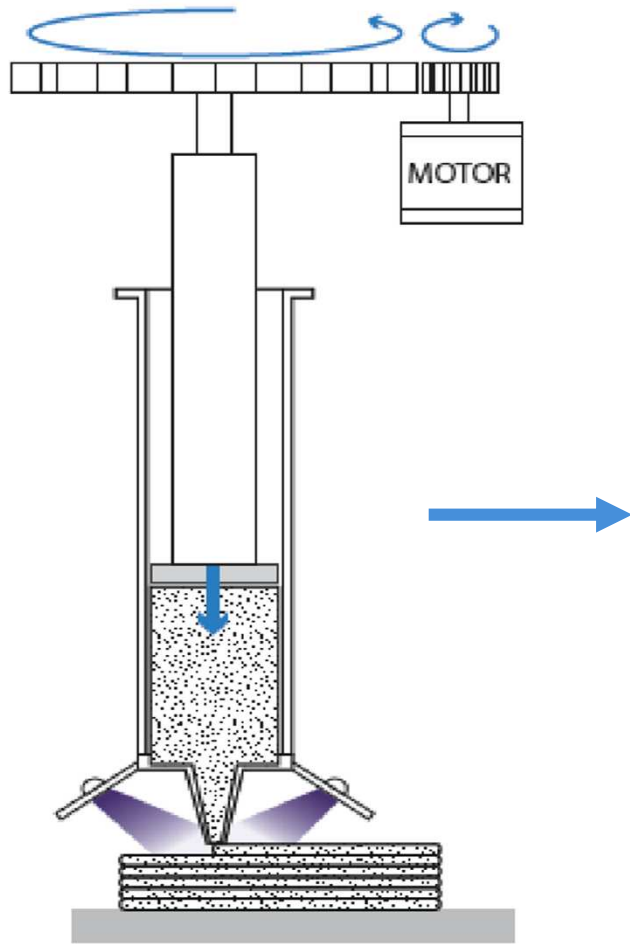
Liquid Deposition Modelling

- materiale allo stato liquido
- sistema di estrusione a pistone
- apparato di polimerizzazione



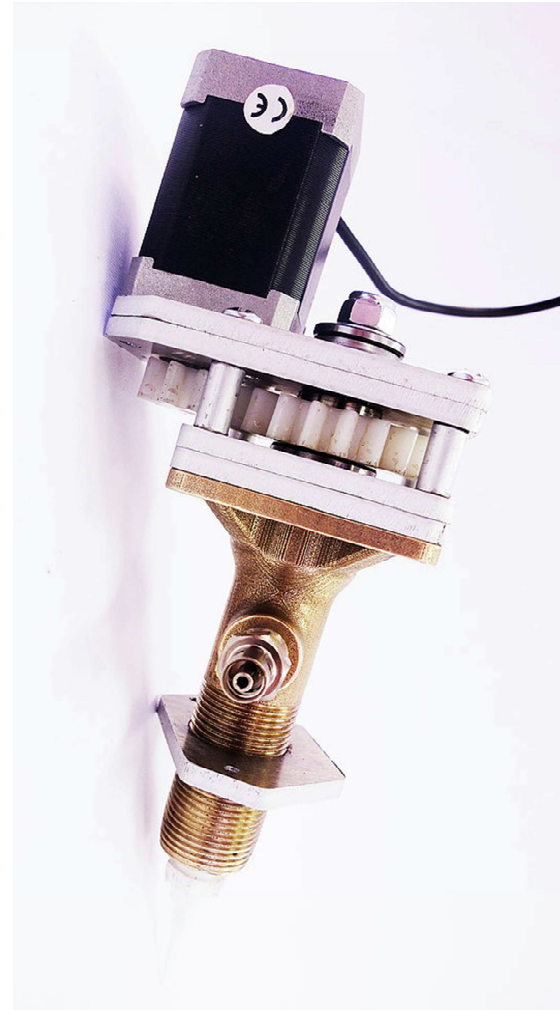
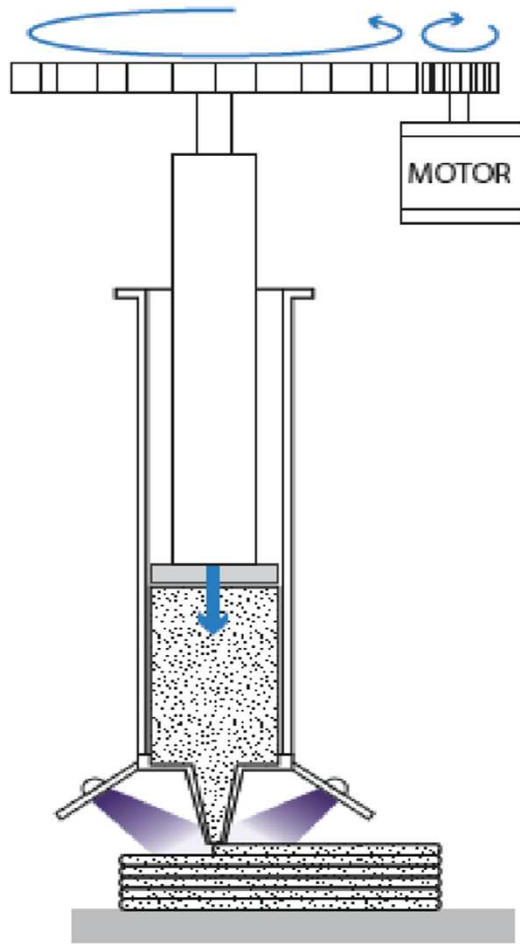
la tecnologia: sistema LDM

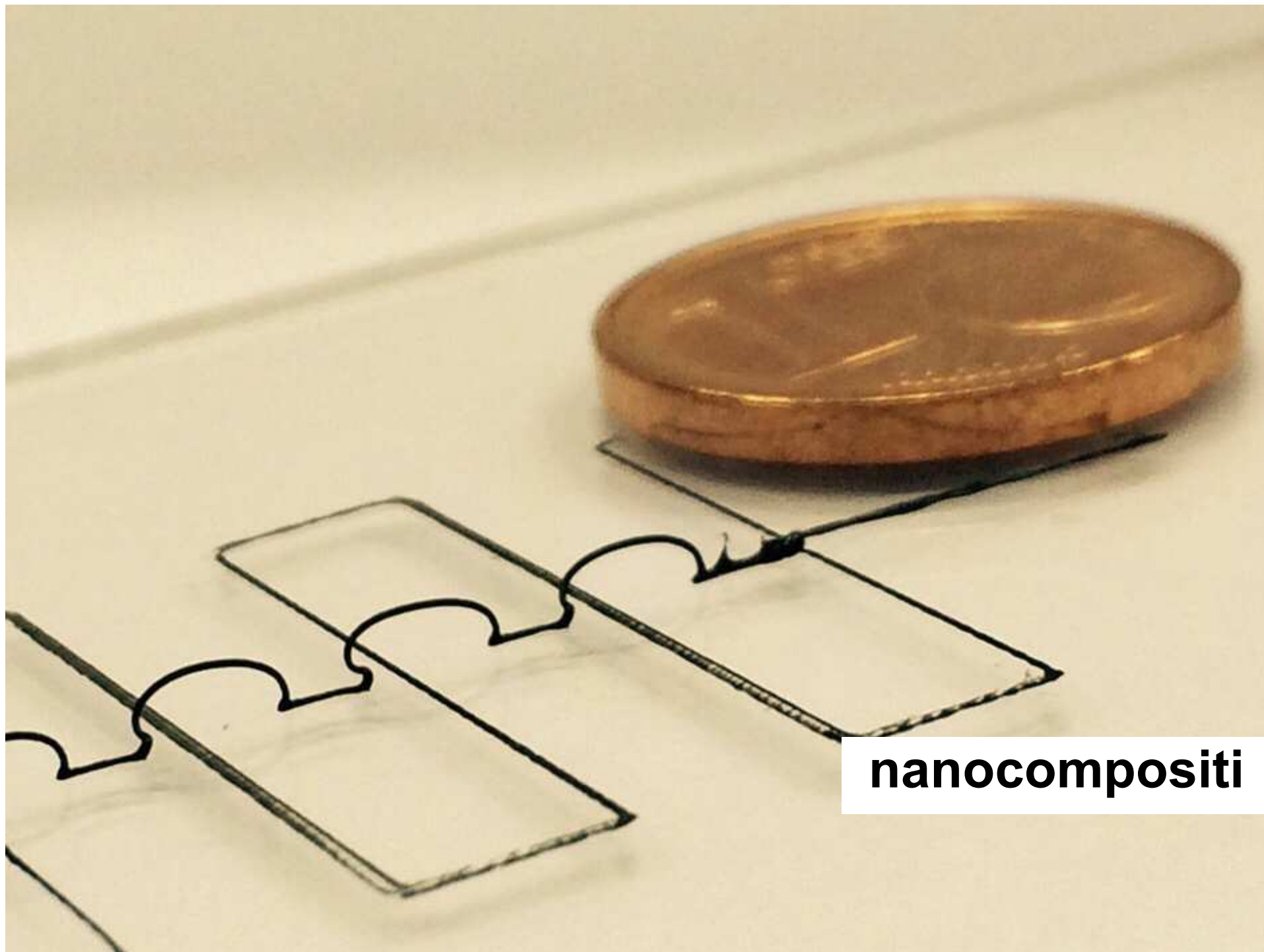
Liquid Deposition Modelling



Evoluzione: un processo continuo

Estrusore a siringa / Estrusore a vite senza fine





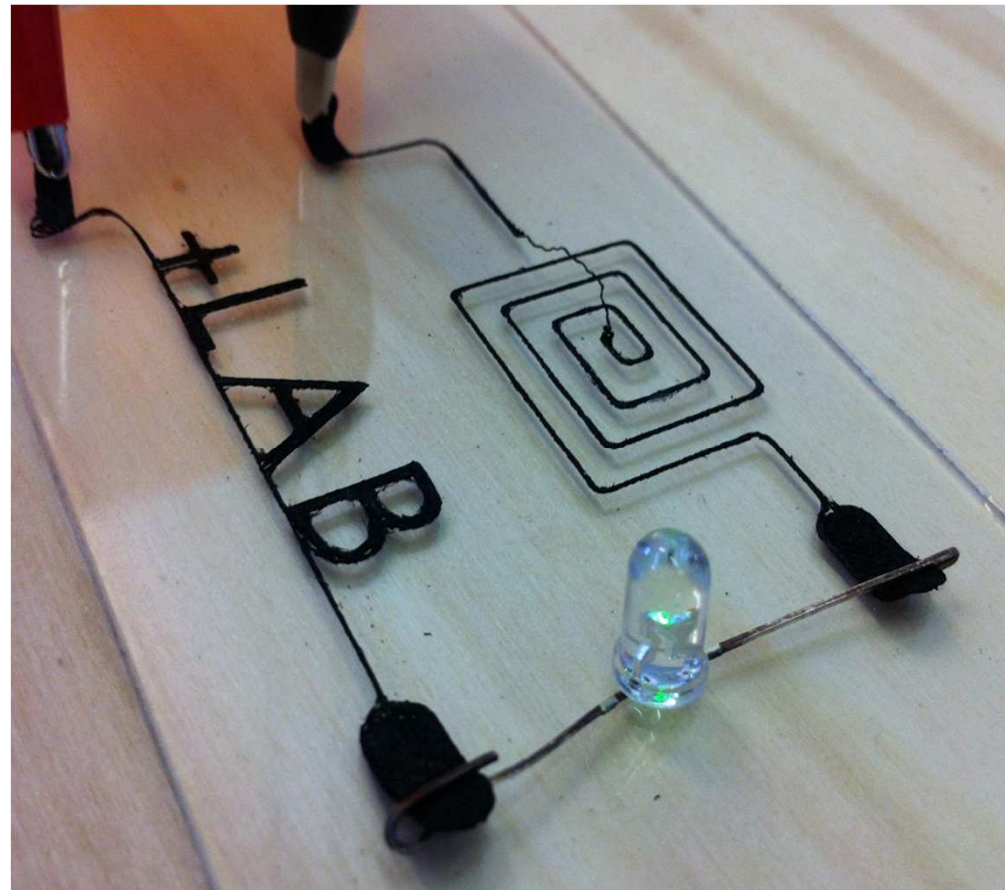
nanocompositi

nanocompositi conduttivi

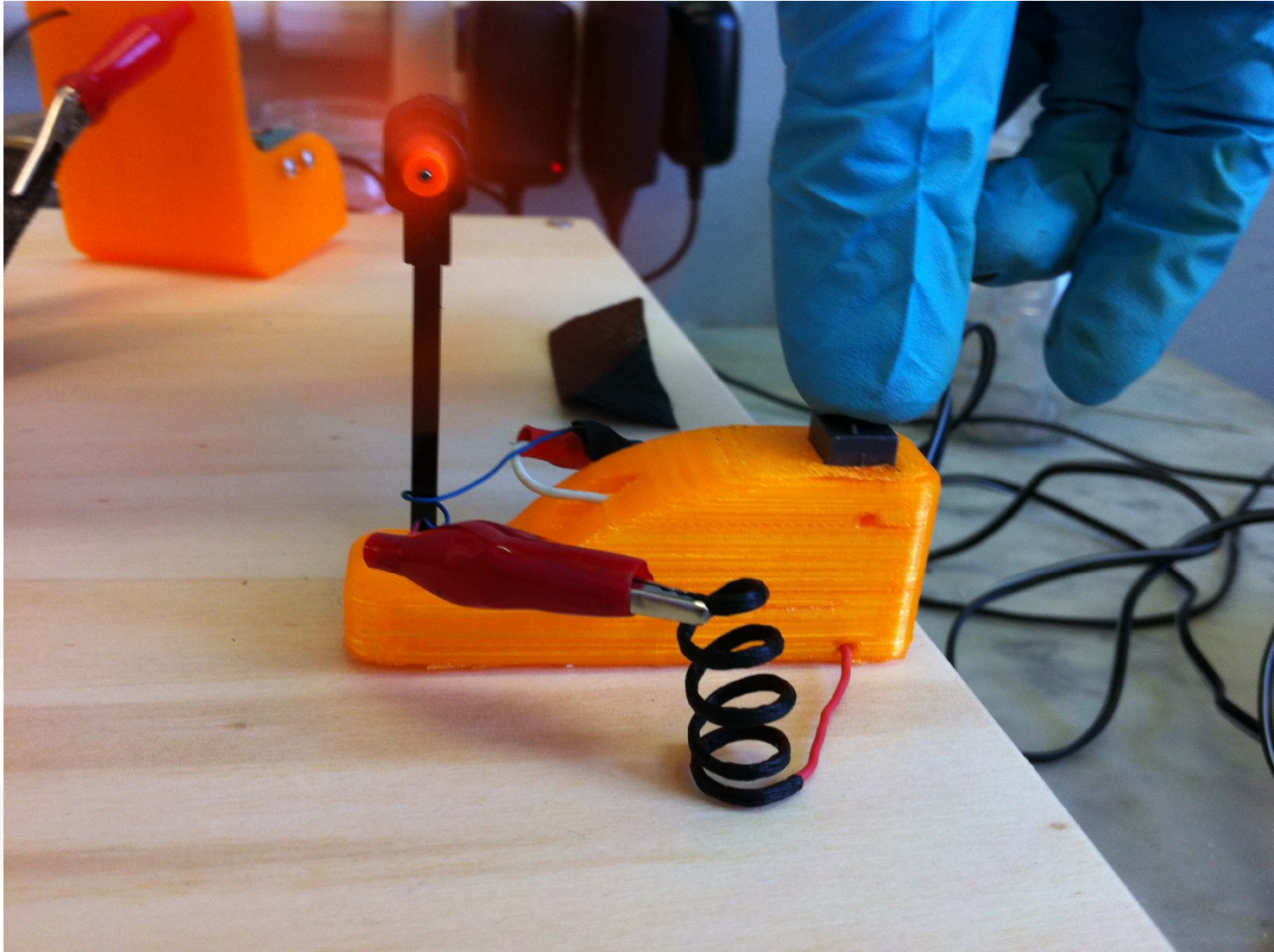
Nanotubi di Carbonio

Grafene

- proprietà meccaniche
- conducibilità elettrica
- conducibilità termica



nanocompositi conduttivi





Compositi a fibra corta

materiale: compositi a fibra corta

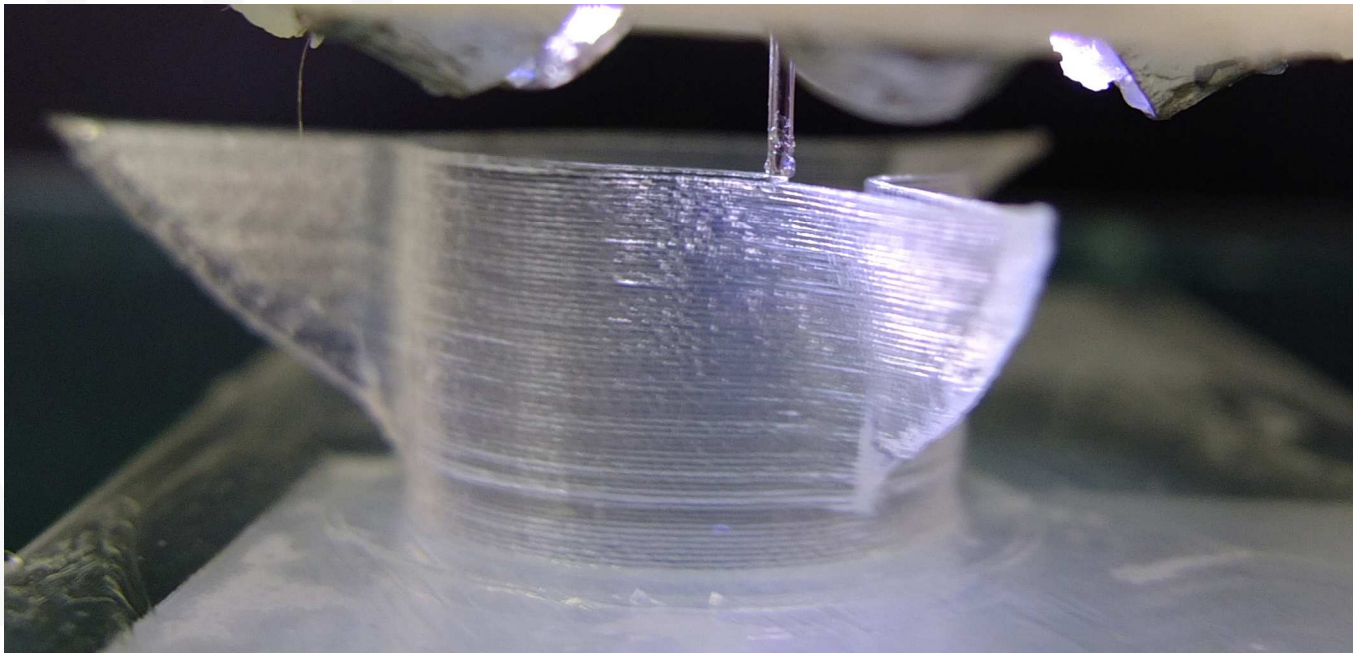
Resina

- Epossidica
- Acrilica
- Poliuretantica
- Poliestere

+

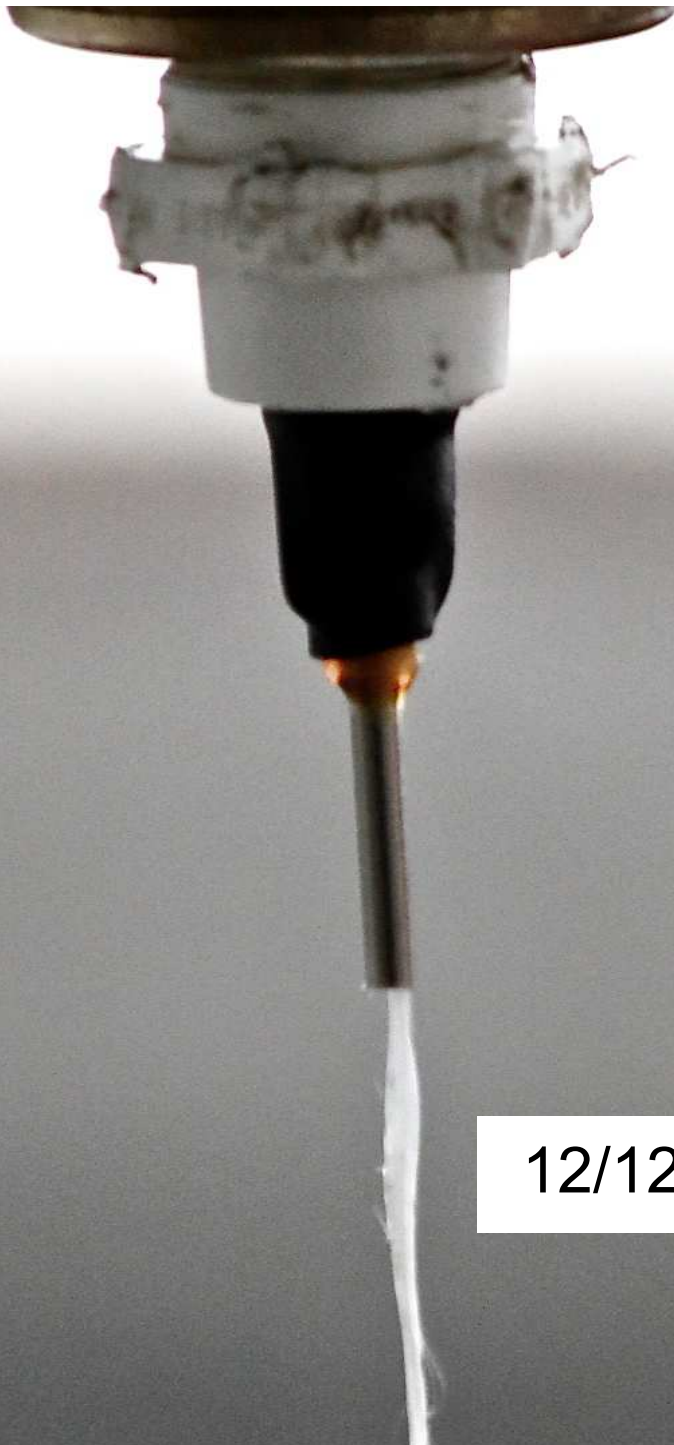
Fibre

- Carbonio
- Vetro
- Kevlar
- Fibre naturali



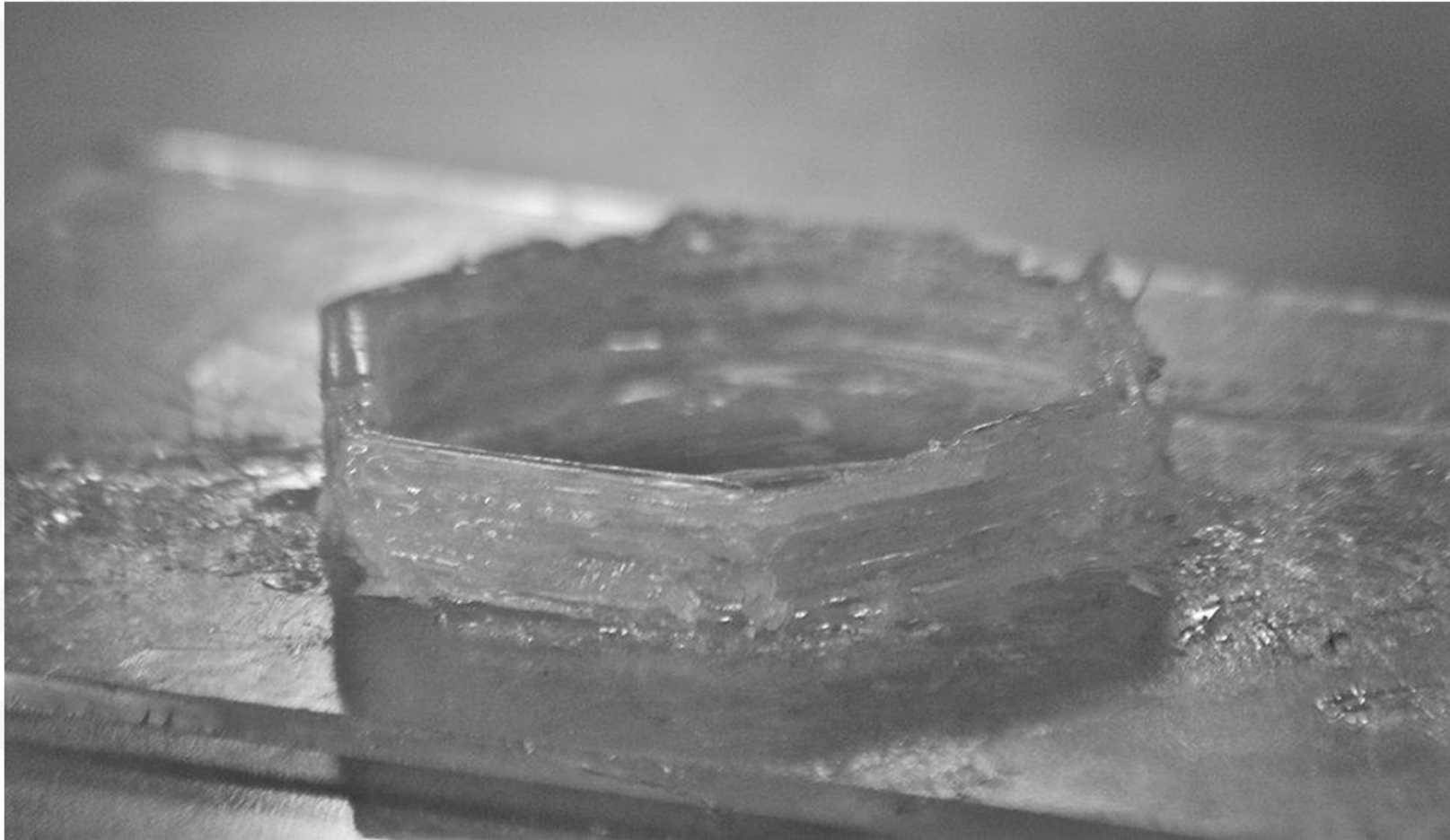
Compositi a fibra corta

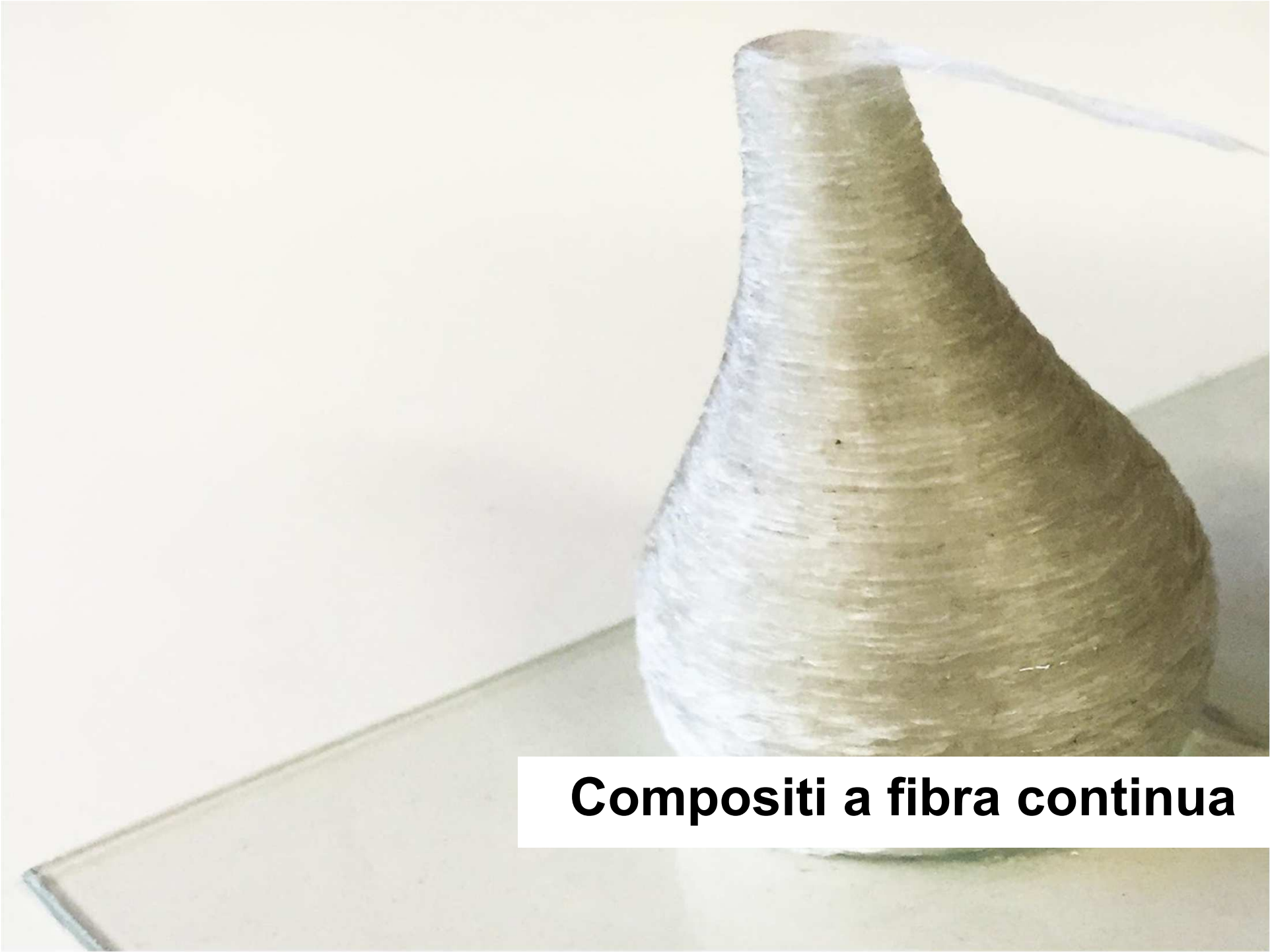




12/12/2014 **Hello World!.gcode**

Il primo pezzo stampato in 3D con resina termoisolante a fibra continua



A photograph of a conical composite part, likely a nozzle or a specialized container, made from a continuous fiber composite. The part is light-colored, possibly white or light gray, and has a smooth, slightly textured surface. It is shaped like a cone with a narrow neck at the top. A thin, light-colored fiber is visible extending from the top of the neck. The part is resting on a flat, light-colored surface. The background is a plain, light-colored wall.

Compositi a fibra continua

Il brevetto

Il sistema di **stampa 3D** di materiali **compositi** a matrice **termoindurente** caricati a **fibra continua** è stato depositato con il nome:

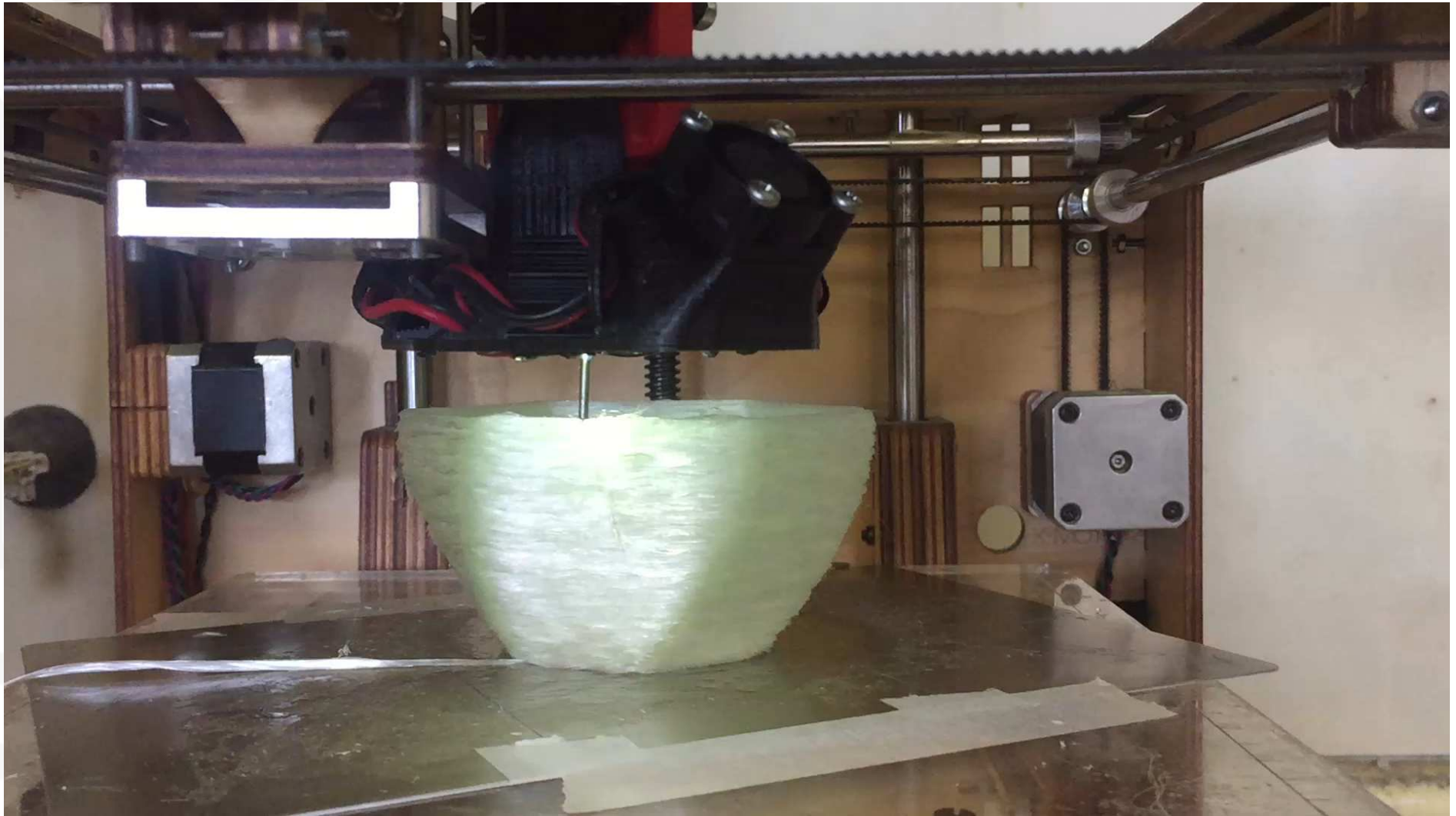
Apparecchiatura e metodo per la
stampa tridimensionale di
materiali compositi a fibra continua

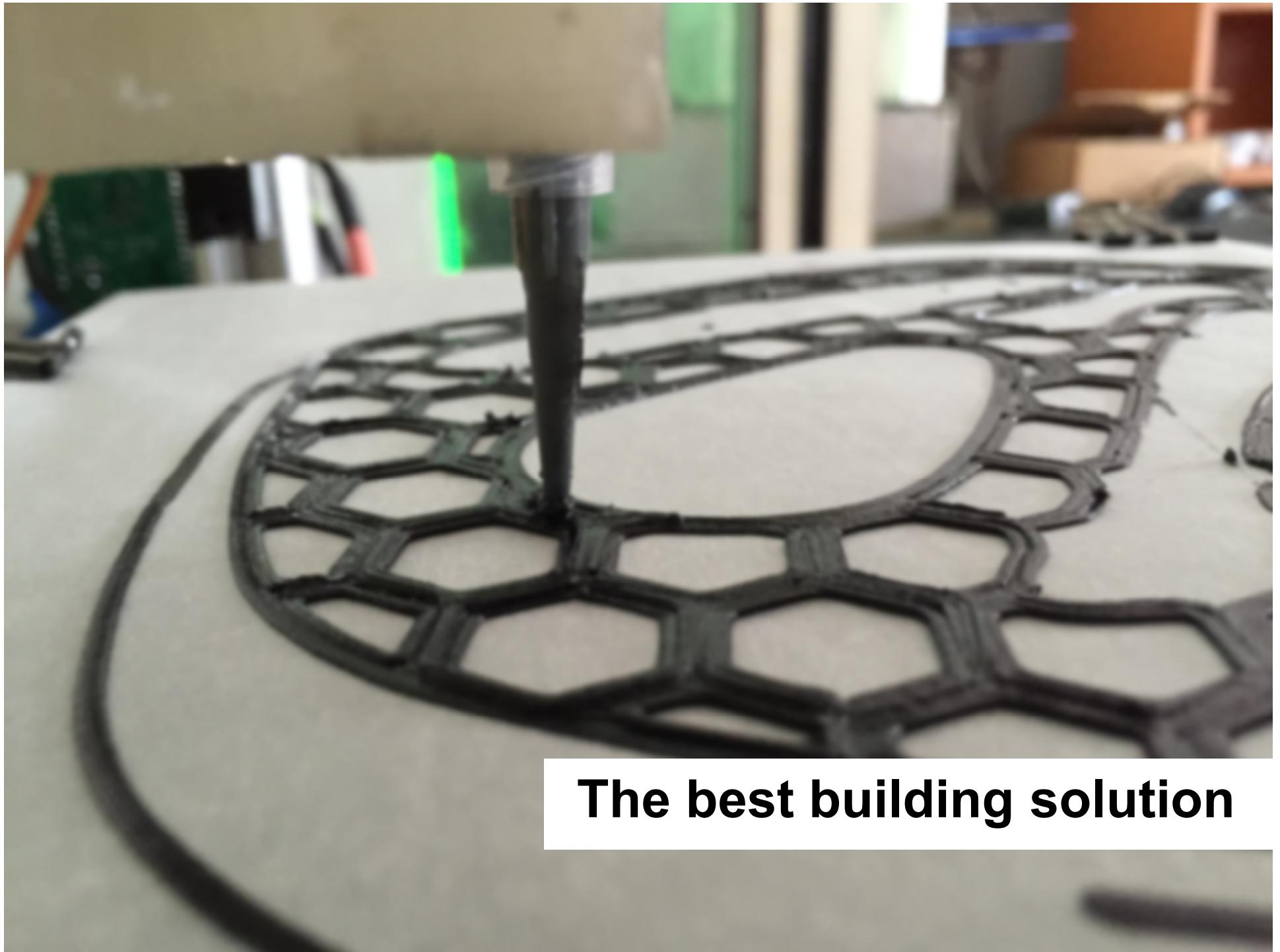
Domanda numero: 102015000073191

la tecnologia:



Il prototipo

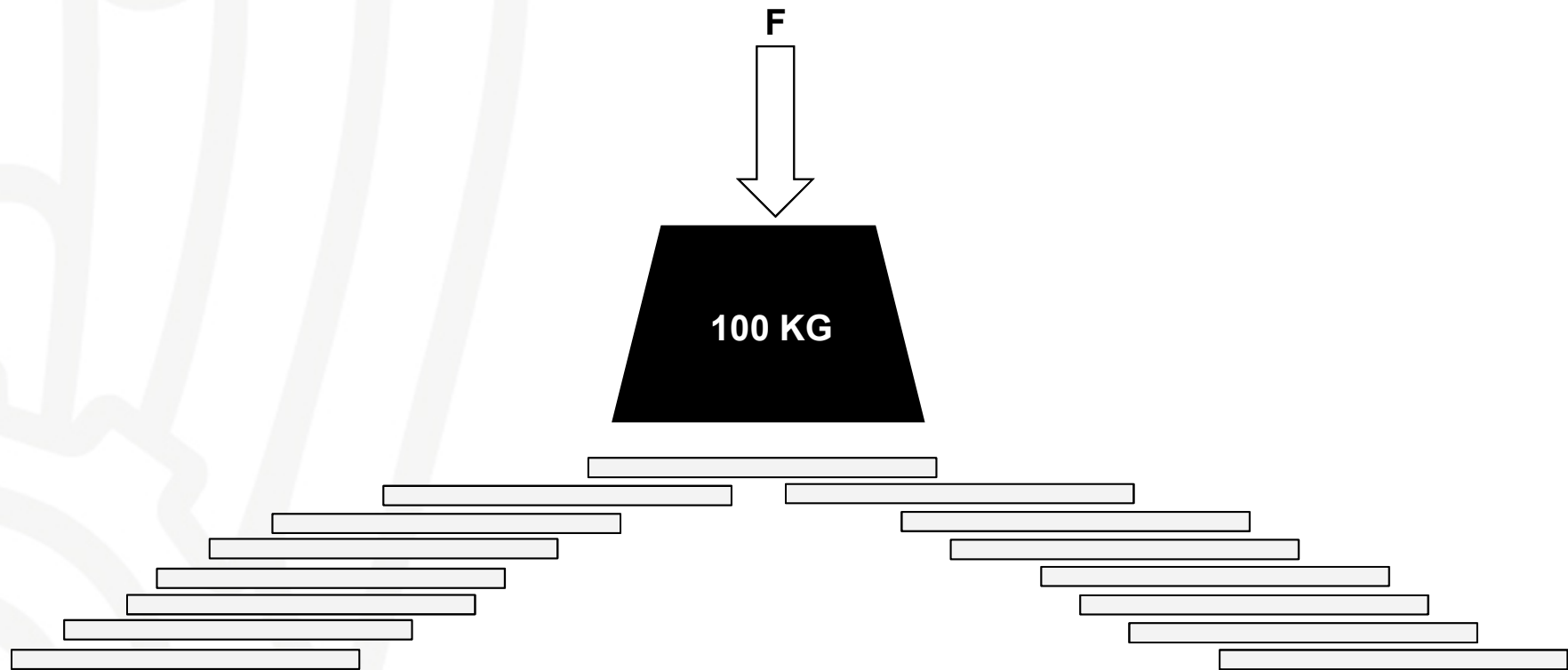




The best building solution

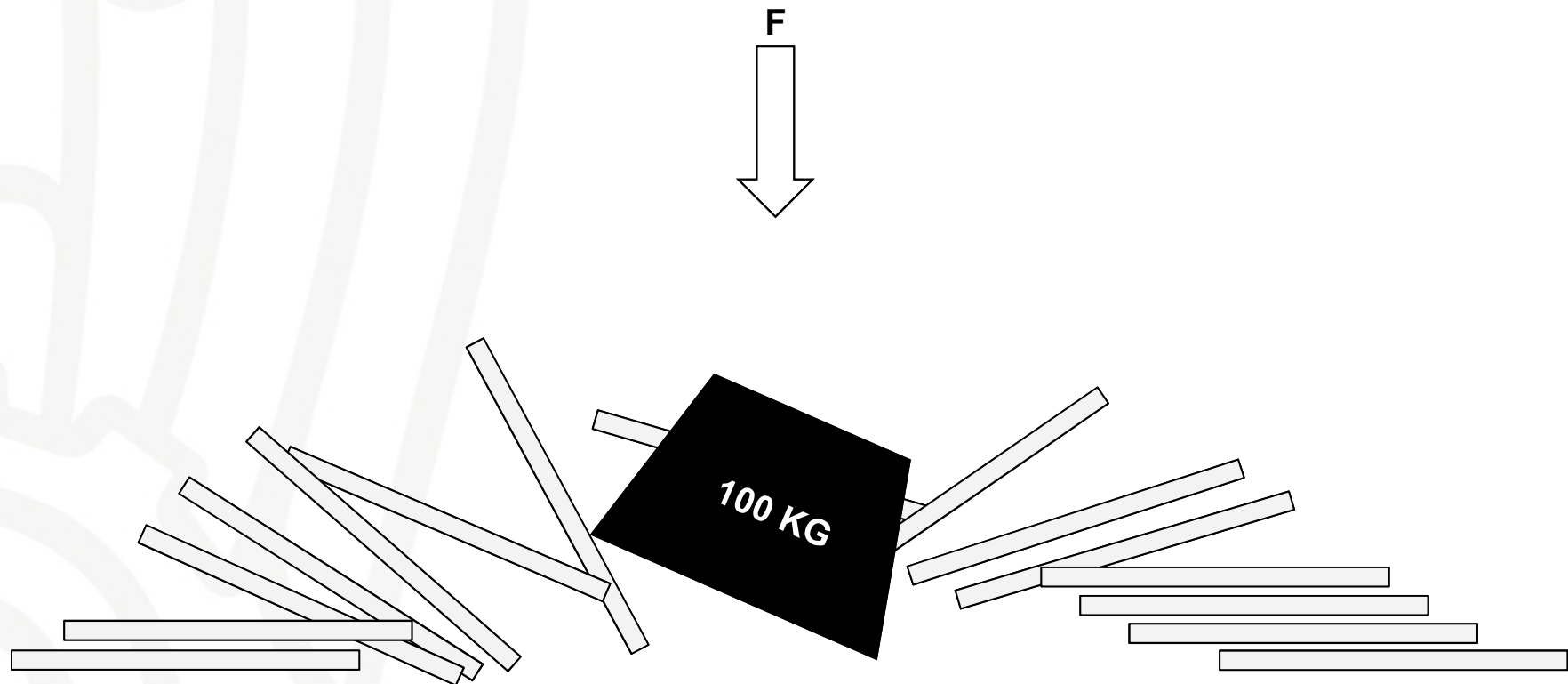
linear slicing vs smart slicing

La stampa 3d layer by layer sfrutta un **sistema di deposizione di materiale a strati paralleli** alla superficie di costruzione.



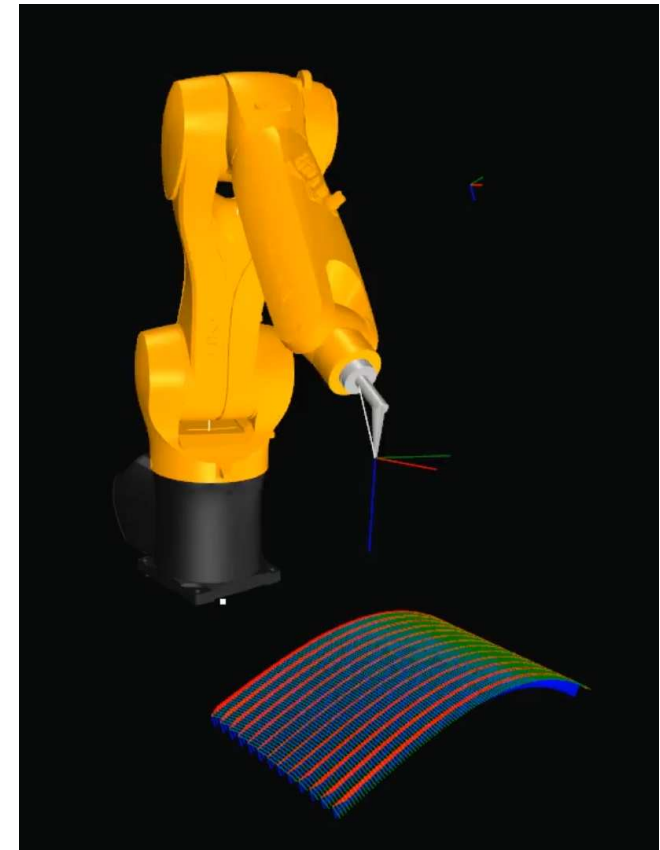
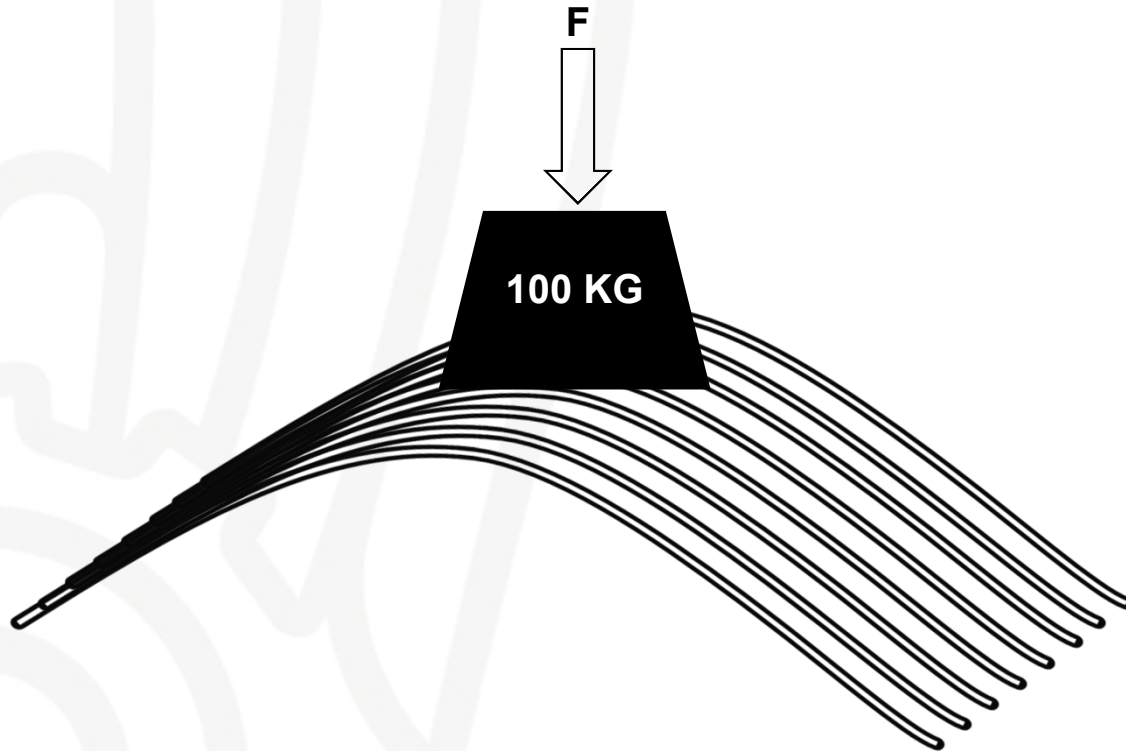
linear slicing

Un sistema di deposizione tradizionale
non è ottimizzato per aumentare le proprietà meccaniche.



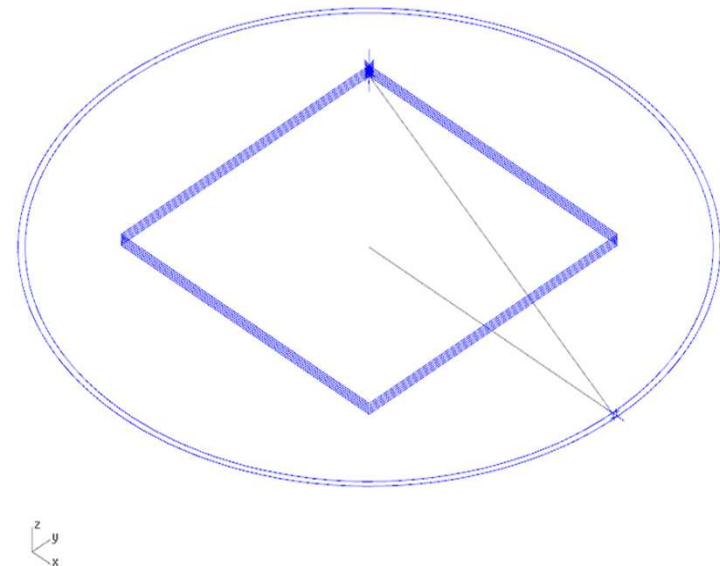
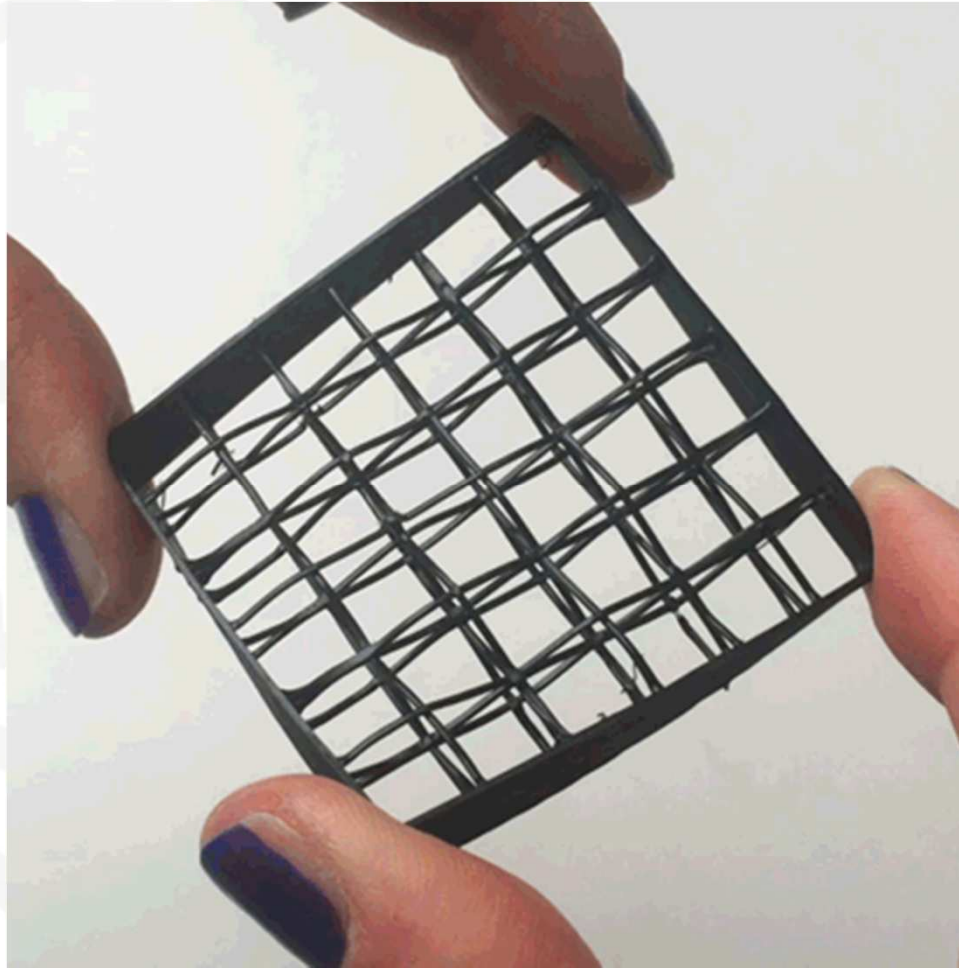
smart slicing

Uno **slicing intelligente** permette di **orientare le fibre in funzione del carico** partendo dal FEM.



smart slicing

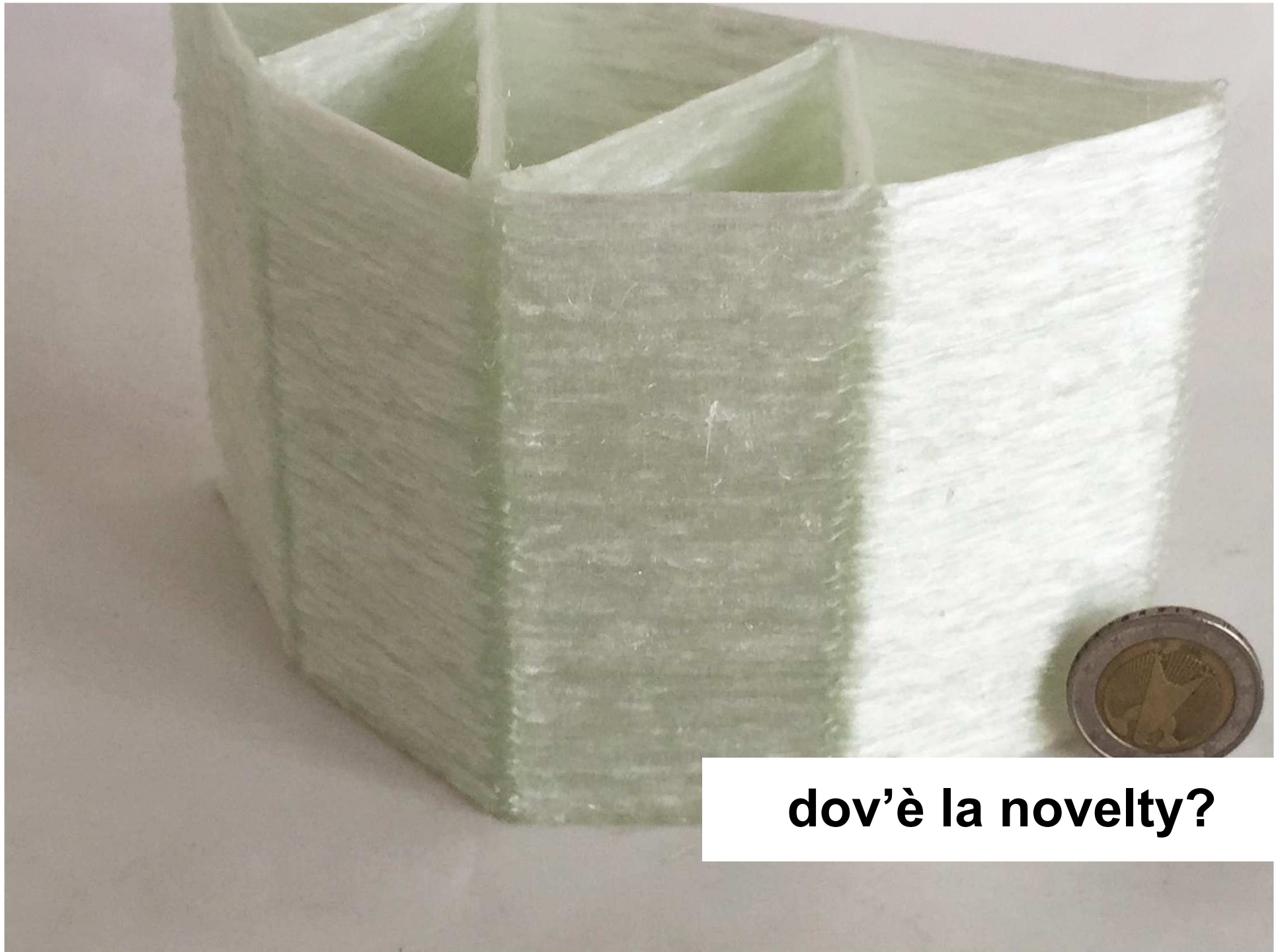
Deposizione **superficiale** e infill



smart slicing: esempio

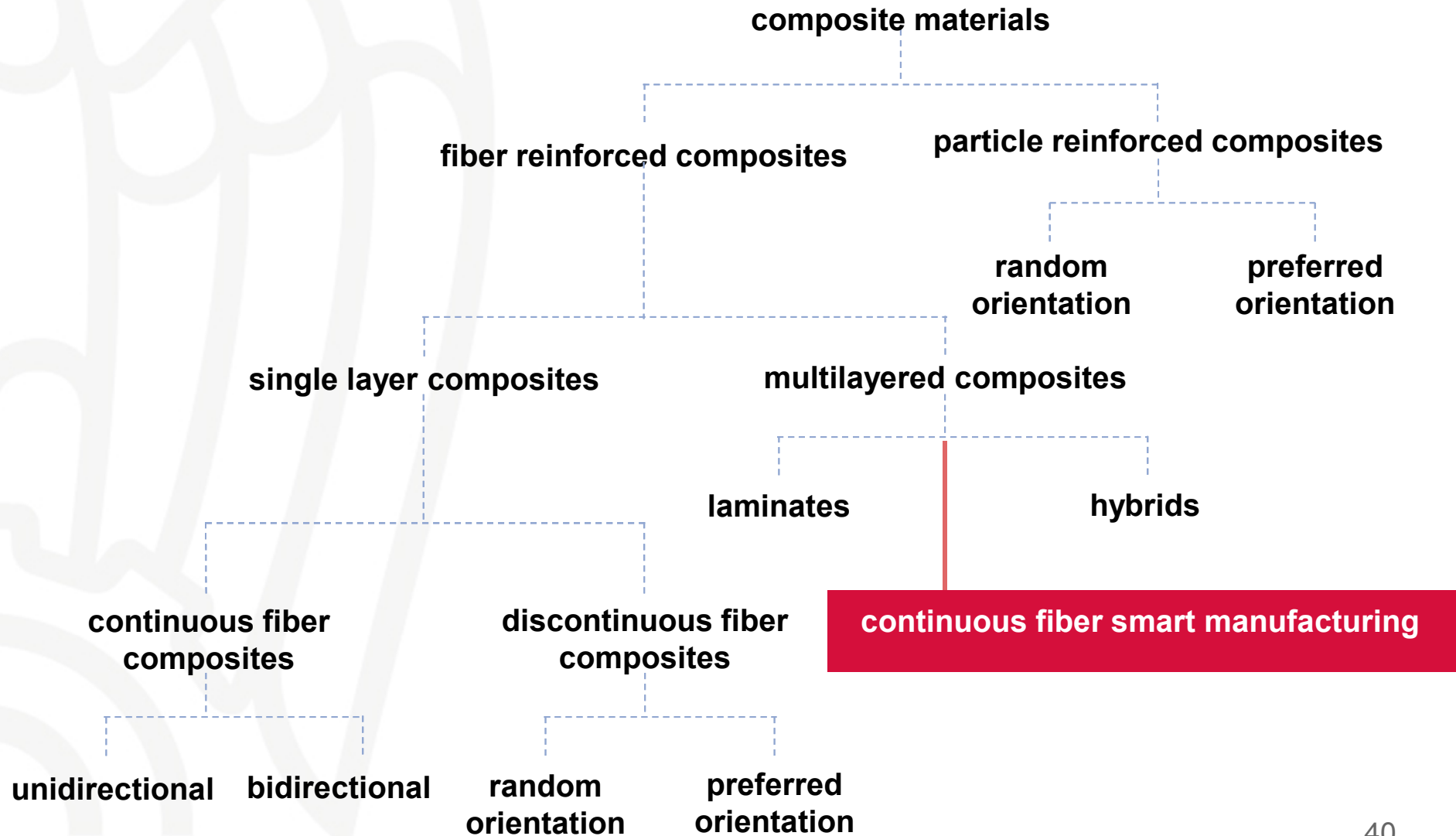


Test fibre di vetro + resina acrilica, **peso 88 gr.**



dov'è la novelty?

Come classificare questo processo?



La complessità è gratuita

Forme complesse fin ora impossibili da realizzare.



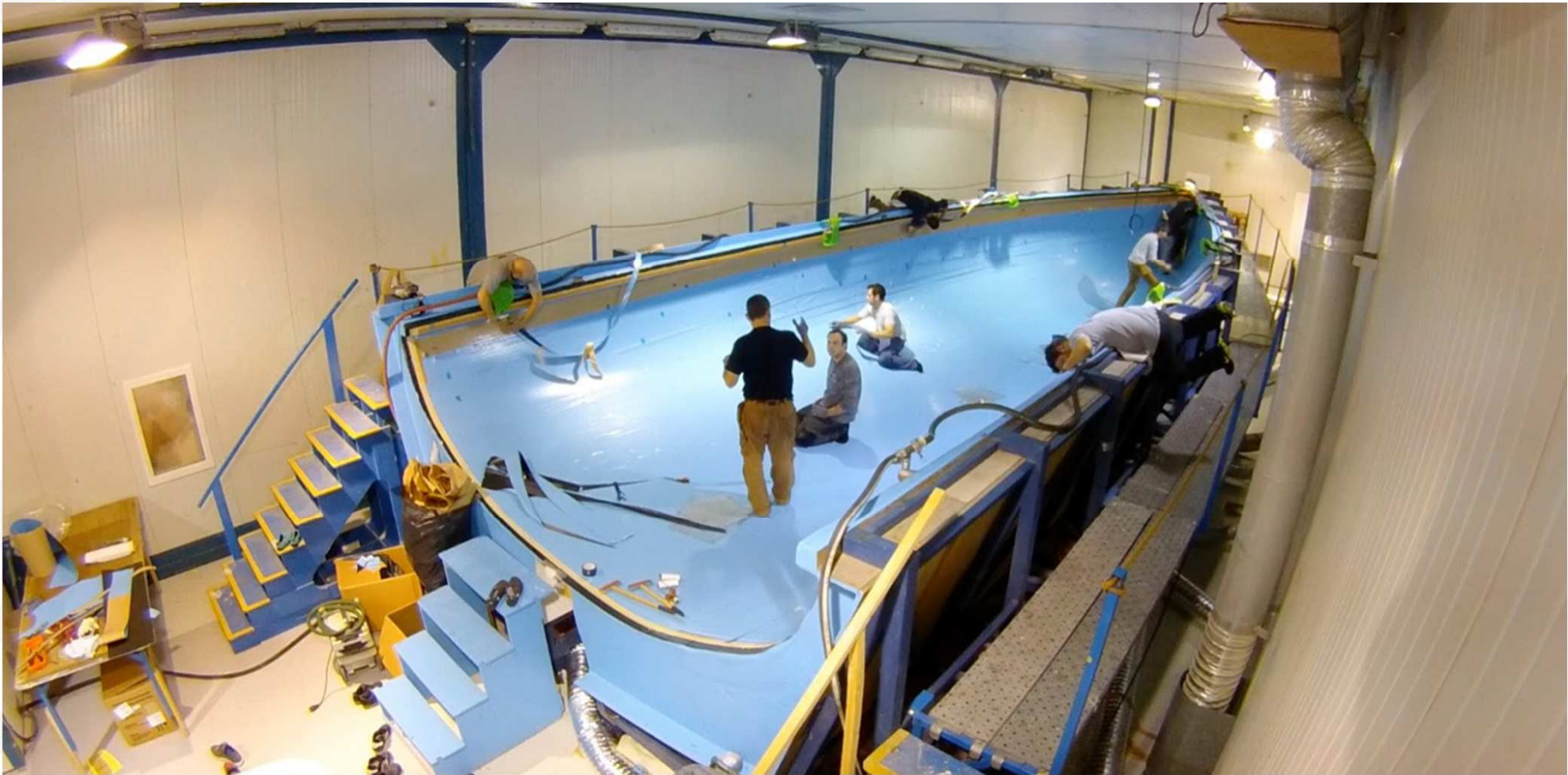
Prestazioni

Elevate prestazioni derivanti dal utilizzo di materiali performanti con un processo di deposizione controllata.



Personalizzazione estrema

Con la stampa 3D produrre 100 oggetti uguali o produrre cento oggetti tutti differenti è la stessa cosa, **non necessita di attrezzature aggiuntive.**



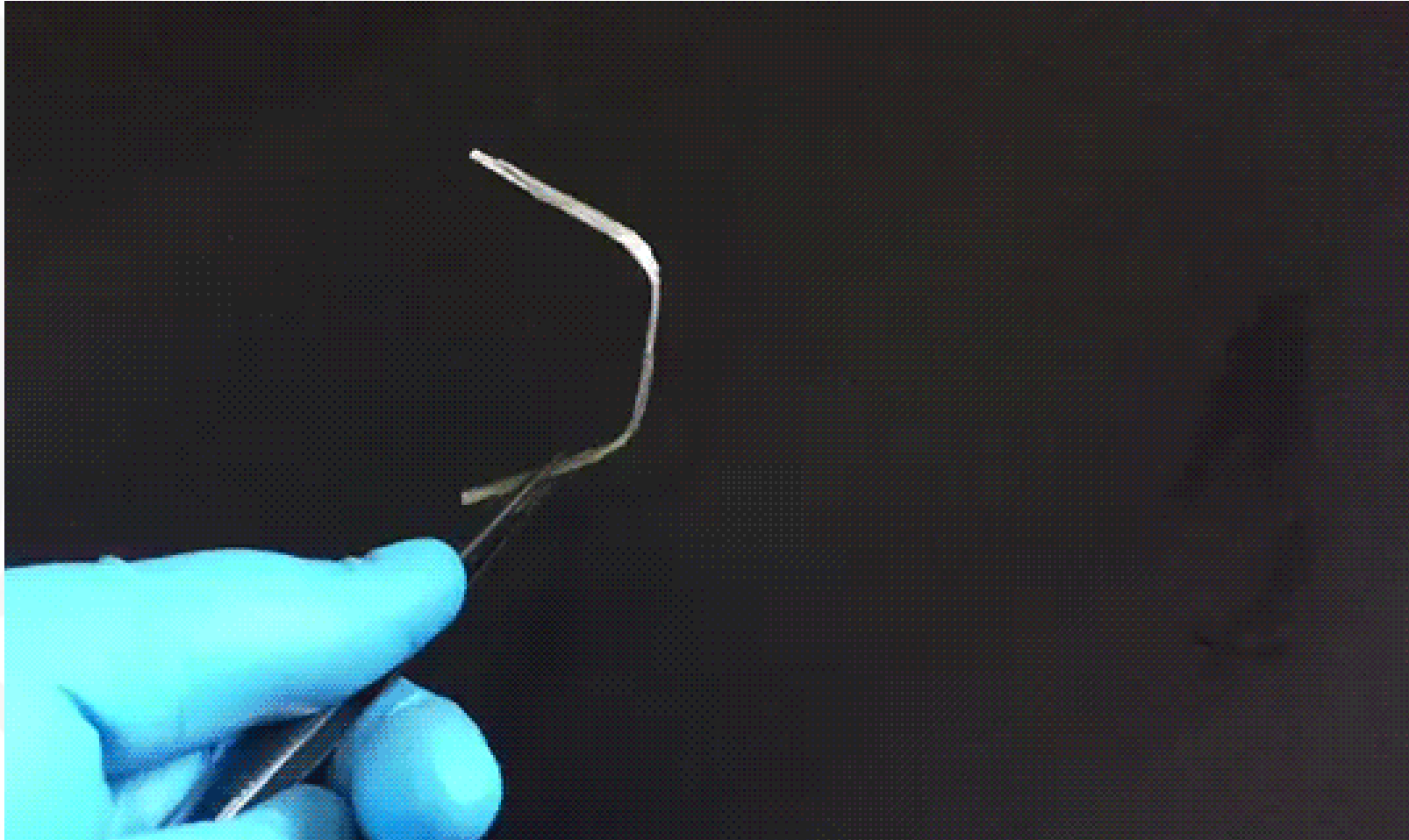
velocità di produzione

Dall'idea al **prodotto** in **breve tempo**.



Strutture adattive e materiali intelligenti

Possibilità di creare **materiali ibridi** e **modulare le proprietà** delle strutture.





l'interesse nel mondo

il mondo della stampa 3d di compositi

With \$1.1 million in bank, MarkForged prepares to deliver first-of-its-kind 3D printer
The Boston Globe 03/07/2014

 New startup raised \$2.8 million for developing a reinforced composite 3D printer
www.3ders.org 16/12/2014

Why Ford is partnering with a hot 3D printing startup
Fortune 23/06/2015

 South Korea to set up \$20M research project for 3D printed ship development in Ulsan
www.3ders.org 27/04/2016

ENVISIONTEC REVEALS SLCOM 1 FOR 3D PRINTING COMPOSITES AT RAPID 2016
TCT Magazine 17/05/2016

 AREVO announces \$7M series A funding round led by Khosla Ventures
3Dprint.com 27/06/2016

il mondo della stampa 3d di compositi

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ENVISIONTEC REVEALS SLCOM 1 FOR 3D PRINTING COMPOSITES AT RAPID 2016

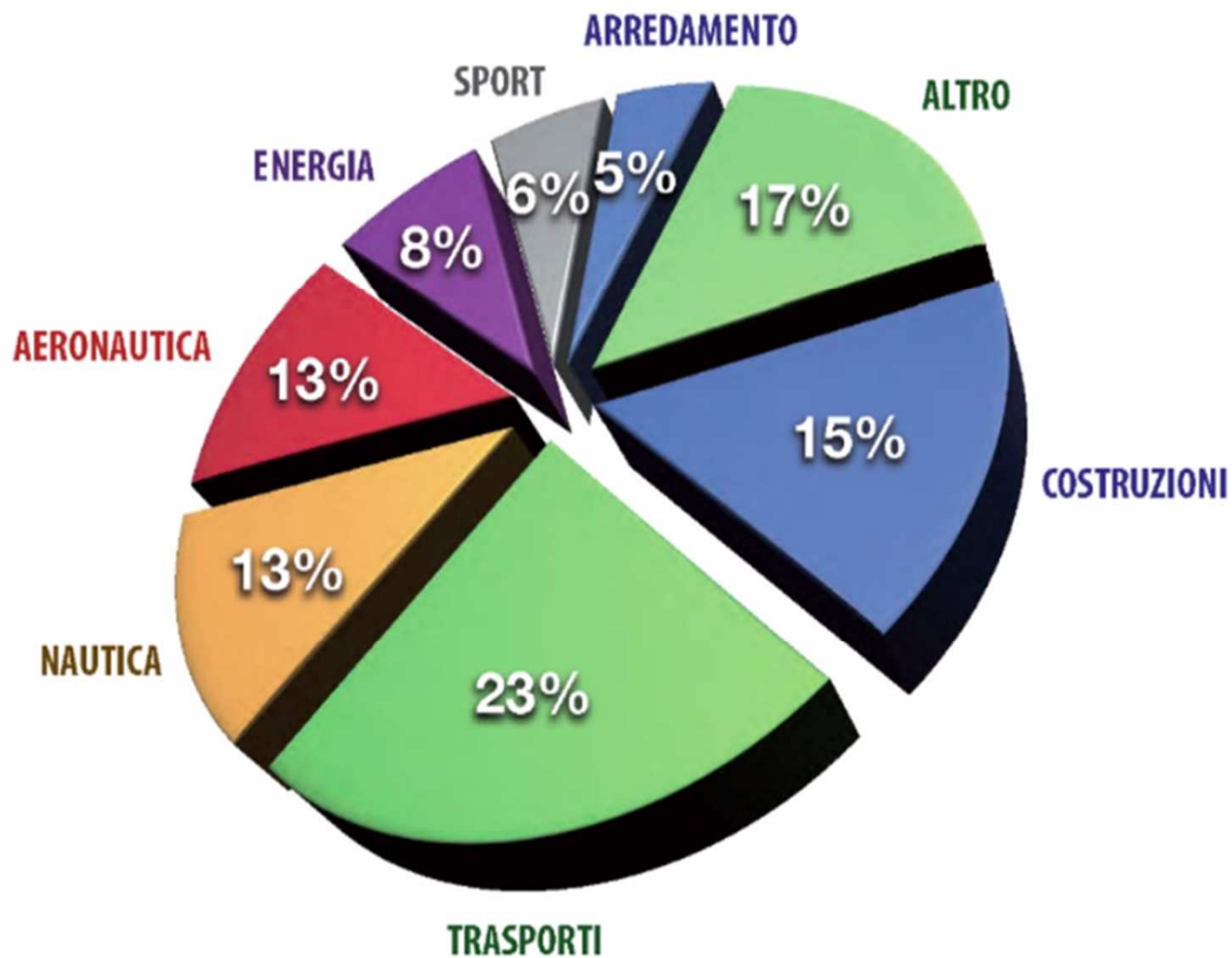
 **AREVO announces \$7M series A funding round led by Khosla Ventures**



dov'è il goal?

il mercato dalle grandi dimensioni

Settori applicativi dei compositi in Italia



Il mercato

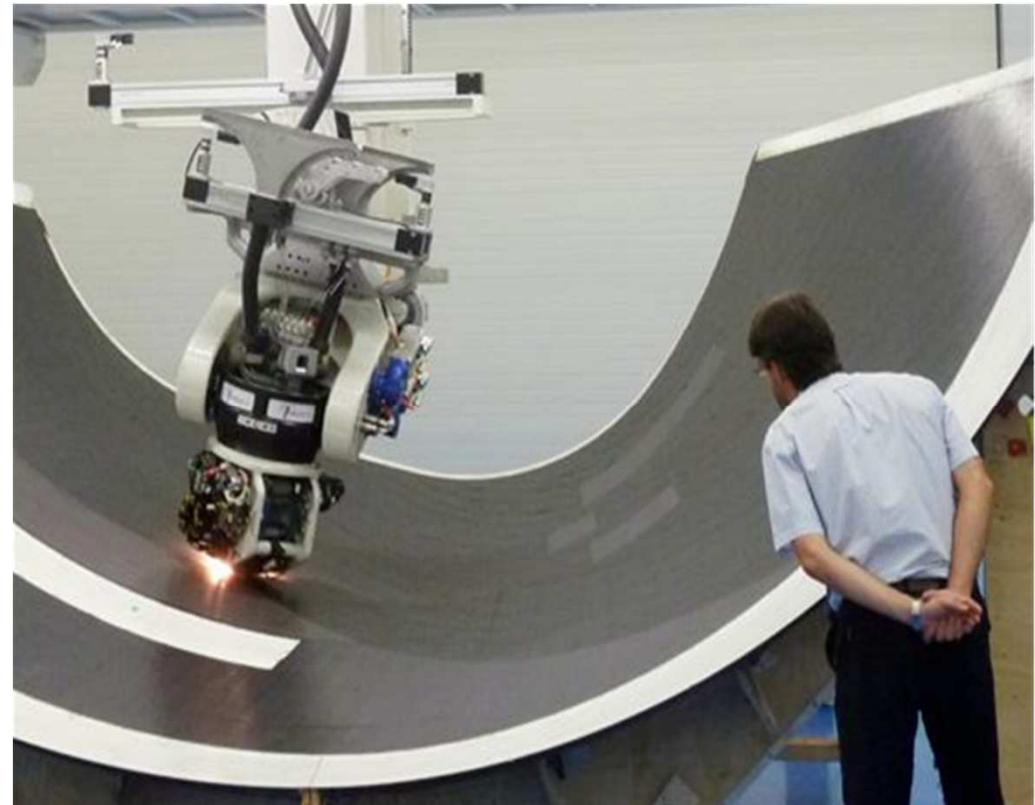
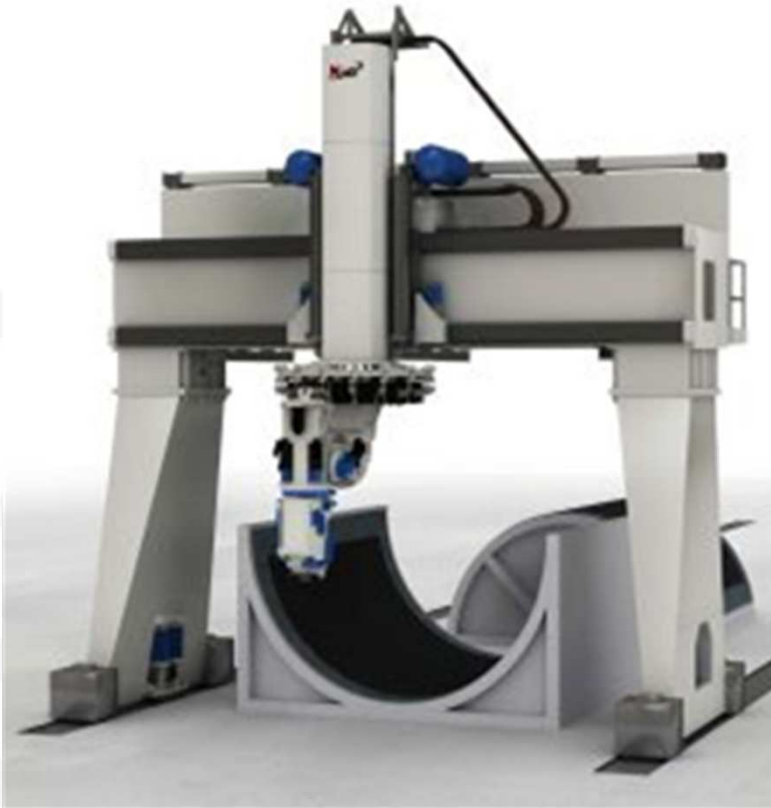
**Elevate Prestazioni
Grandi Dimensioni**



**ALTO VALORE
AGGIUNTO**

big machine

Adattare la tecnologia CFSM ad una macchina di **grandi dimensioni** simile a quelle utilizzate nei sistemi di **Fiber Placement Manufacturing**.



Obiettivi futuri

1 • Movimentazione su **più di 3 assi**.



2 • Aumentare la **velocità** dotando il sistema di un apparato di polimerizzazione più performante.

3 • Nuovi **materiali** ad attivazione termica.

4 • **Spin-off**.



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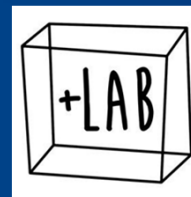
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Referenze

APPARECCHIATURA E METODO PER LA STAMPA TRIDIMENSIONALE DI MATERIALI COMPOSITI A FIBRA CONTINUA

DATA DI PUBBLICAZIONE

2015-11-30

CODICE

CH.15.021.A



Short communication

3D-printable CFR polymer composites with dual-cure sequential IPNs

Gianmarco Griffini, Marta Invernizzi, Marinella Levi, Gabriele Natale, Giovanni Postiglione, Stefano Turri*



Short communication

Conductive 3D microstructures by direct 3D printing of polymer/carbon nanotube nanocomposites *via* liquid deposition modeling

Giovanni Postiglione, Gabriele Natale, Gianmarco Griffini*, Marinella Levi, Stefano Turri



Article

UV-assisted three-dimensional printing of polymer nanocomposites based on inorganic fillers

Giovanni Postiglione, Gabriele Natale, Gianmarco Griffini*, Marinella Levi and Stefano Turri

Version of Record online: 25 AUG 2015

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http://www.polimi.it/index.php?id=6247&sel_breve_tto=5066

<http://www.sciencedirect.com/science/article/pii/S0032386116301884>

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<http://onlinelibrary.wiley.com/doi/10.1002/pc.23735/abstract>