SPECIFICS OF 3D-PRINTED ELECTRONICS

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MOTIVATION

3D printing -- also known as additive manufacturing -- offers number of benefits for production of innovative electronic objects that could not have been produced through conventional means.

Electronics and parts manufacturers can improve their technologies such as: by printing on non-flat surfaces, have opportunity of mass customization, get lower material wastage, avoid usage of harmful chemicals, reduce product dimensions, and simplify assembly.

Research of materials

Additive technologies also vary by the type of materials they can use. The list of materials available for 3D-printed electronics is currently limited, but growing mainly due to development of new nano-materials.

3D-printed microelectronics for integrated circuitry and passive wireless sensors

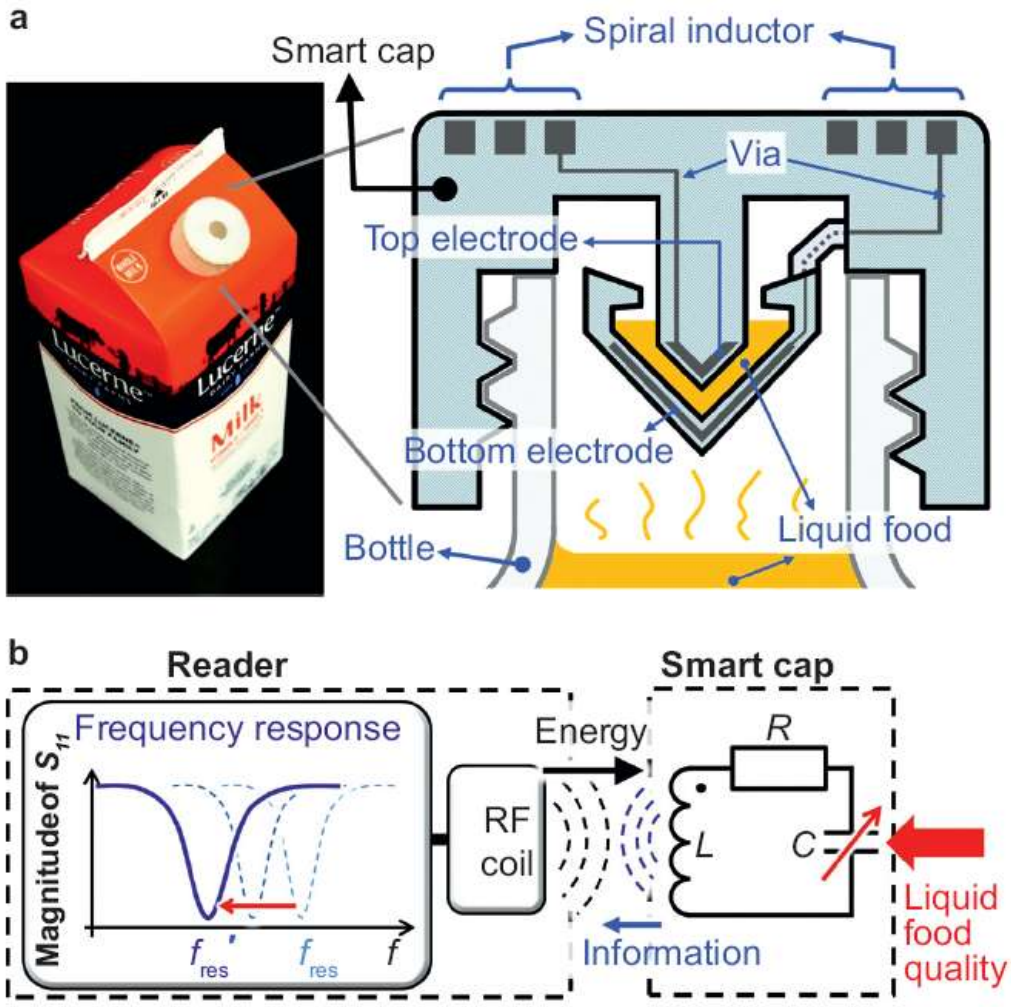
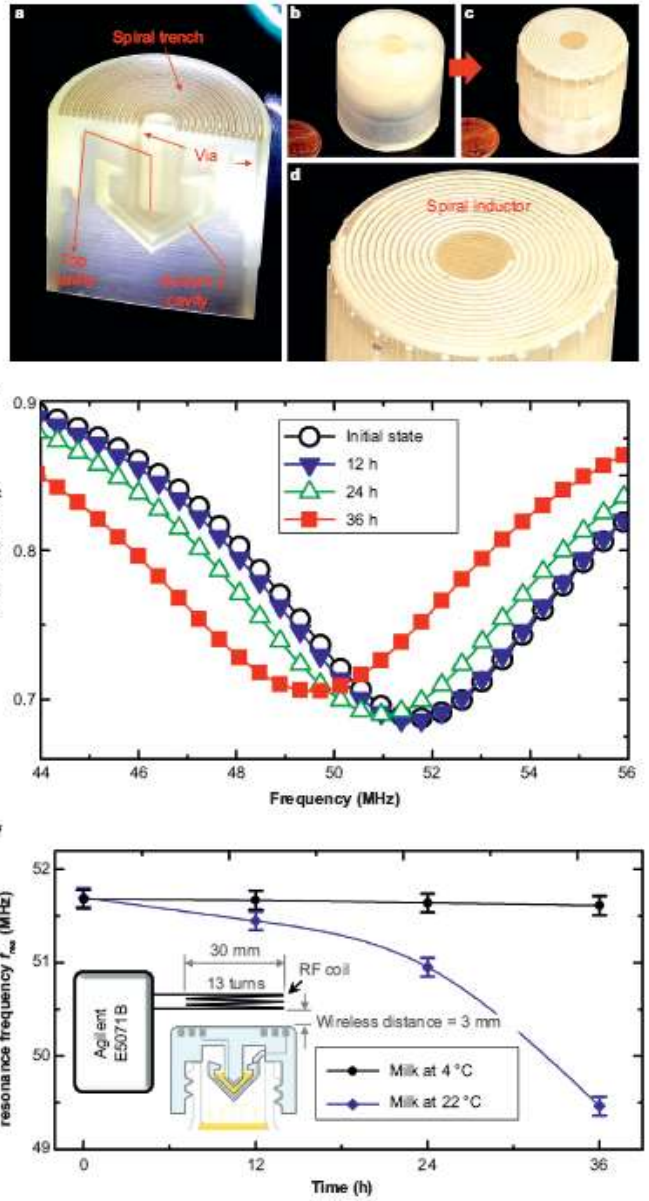
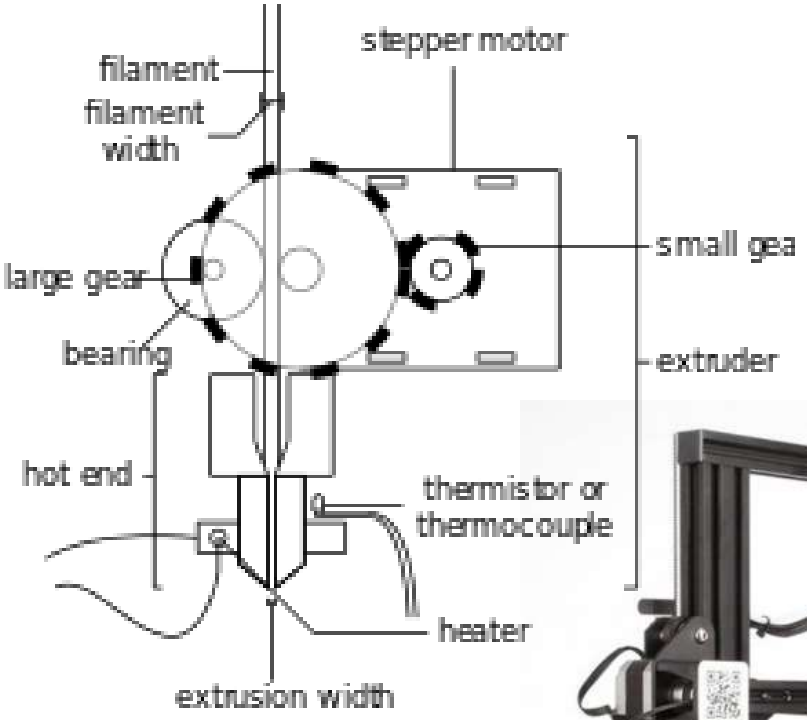


Figure 5 The proposed "smart cap" for rapid detection of liquid food quality featuring wireless readout: (**a**) the smart cap with a half-gallon milk package, and the cross-sectional schematic diagram; (**b**) sensing principle with the equivalent circuit diagram.



Microsystems &Nano-engineering (2015) 1, 15013;

Fused filament deposition



Prusa i3 MK3

Creality Ender 3

Source: ALL3DP

Suitable Materials

Poly(lactic acid) or **polylactic acid** or **polylactide** (**PLA**) is a biodegradable and bioactive thermoplastic aliphatic polyester derived from renewable resources.

Acrylonitrile butadiene styrene (ABS) ranks as the second most popular 3D printer filament, after PLA. But that just means it's the second most commonly *used*. With respect to its material properties, ABS is actually moderately superior to PLA, despite being slightly more difficult to print with. It's for this reason that ABS is found in many manufactured household and consumer goods.

When types of 3D printer filament like PLA, ABS, PETG, and nylon are reinforced with carbon fiber, the result is an extremely stiff and rigid material with relatively little weight. Such compounds shine in structural applications that must withstand a wide variety of end-use environments.

PLA *vs* ABS

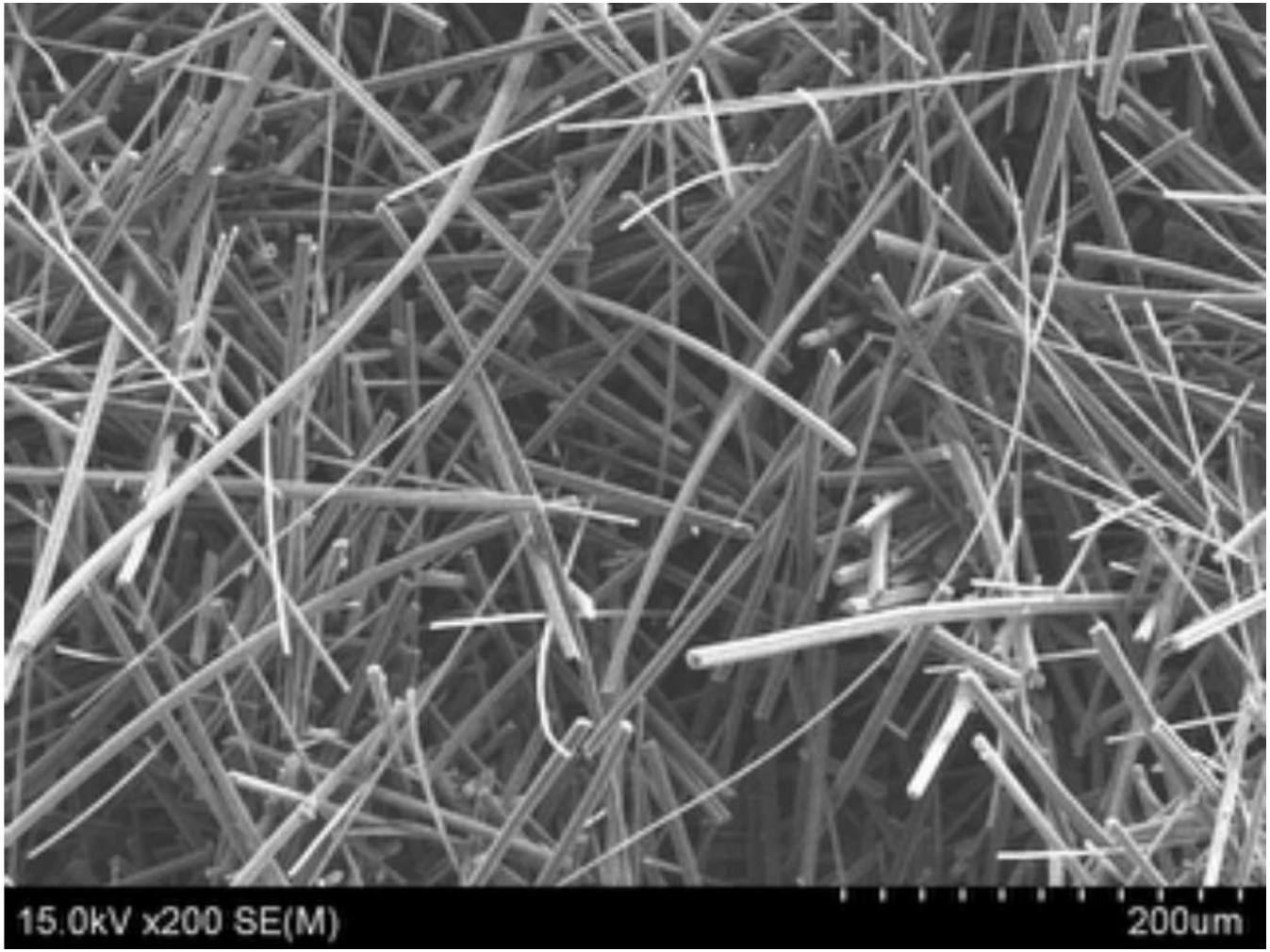
Temperature	PLA	ABS
Printing Temperature	180-230°C	210-250°C
Print Bed Temperature	20-60°C	80-110°C
Print Bed	Optional	Mandatory
Enclosure	Optional	Recommended
Clogs/Jams Nozzle	Occasionally	Never
First Layer Adhesion	Minor problems	Minor problems
Fumes	Little to none	Bad and intense
Absorbs Moisture	Yes	Yes

- Shape of the prototype distributed 3D-printed resistor has been chosen as parallelepiped with truncated pyramids at the both ends serving as the contact adapters.

- Overall sample dimensions were 30×10×10 mm and its structure represents 3D cubic lattice.

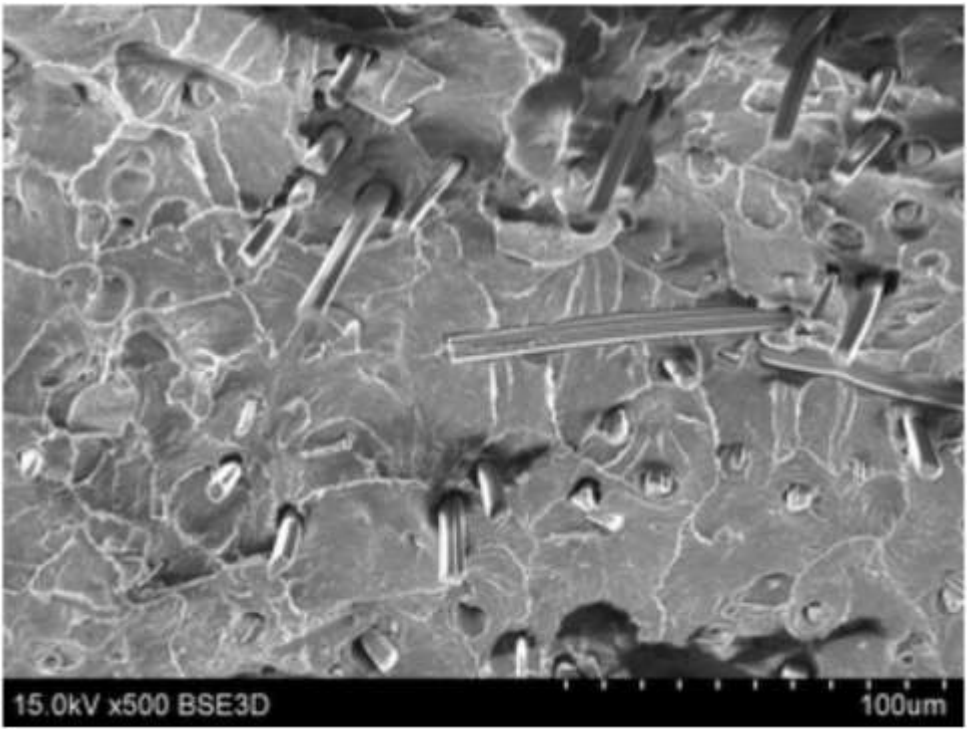
- ABS plastic filled by carbon fibers of various concentrations was used as material for the printing.

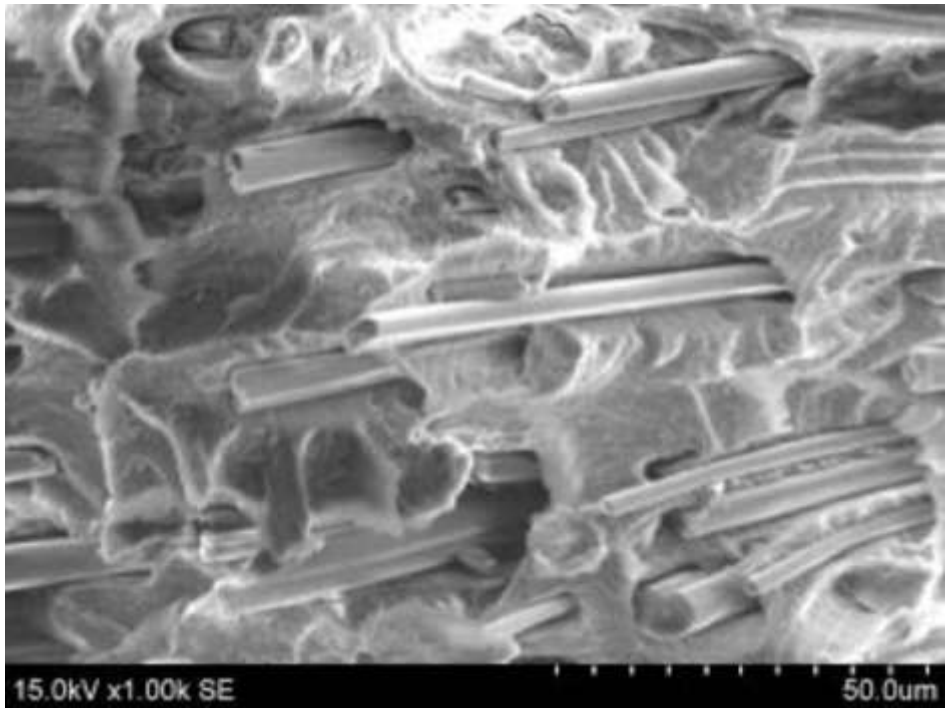
Carbon fibers



Carbon fibers or graphite fibers are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion.

ABS with 6% and 15% carbon fibers

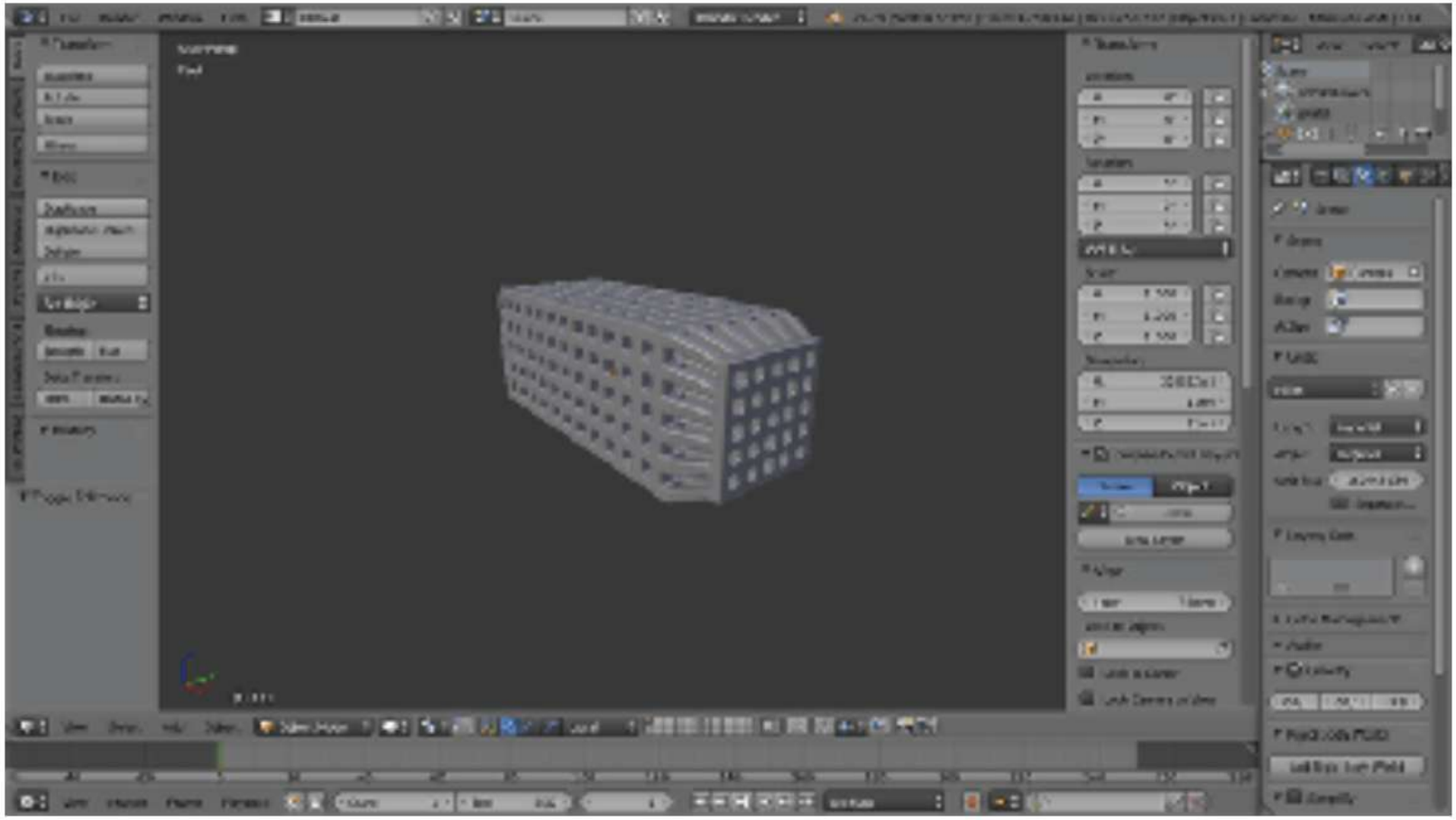




3D printer PREMIER 3D N1

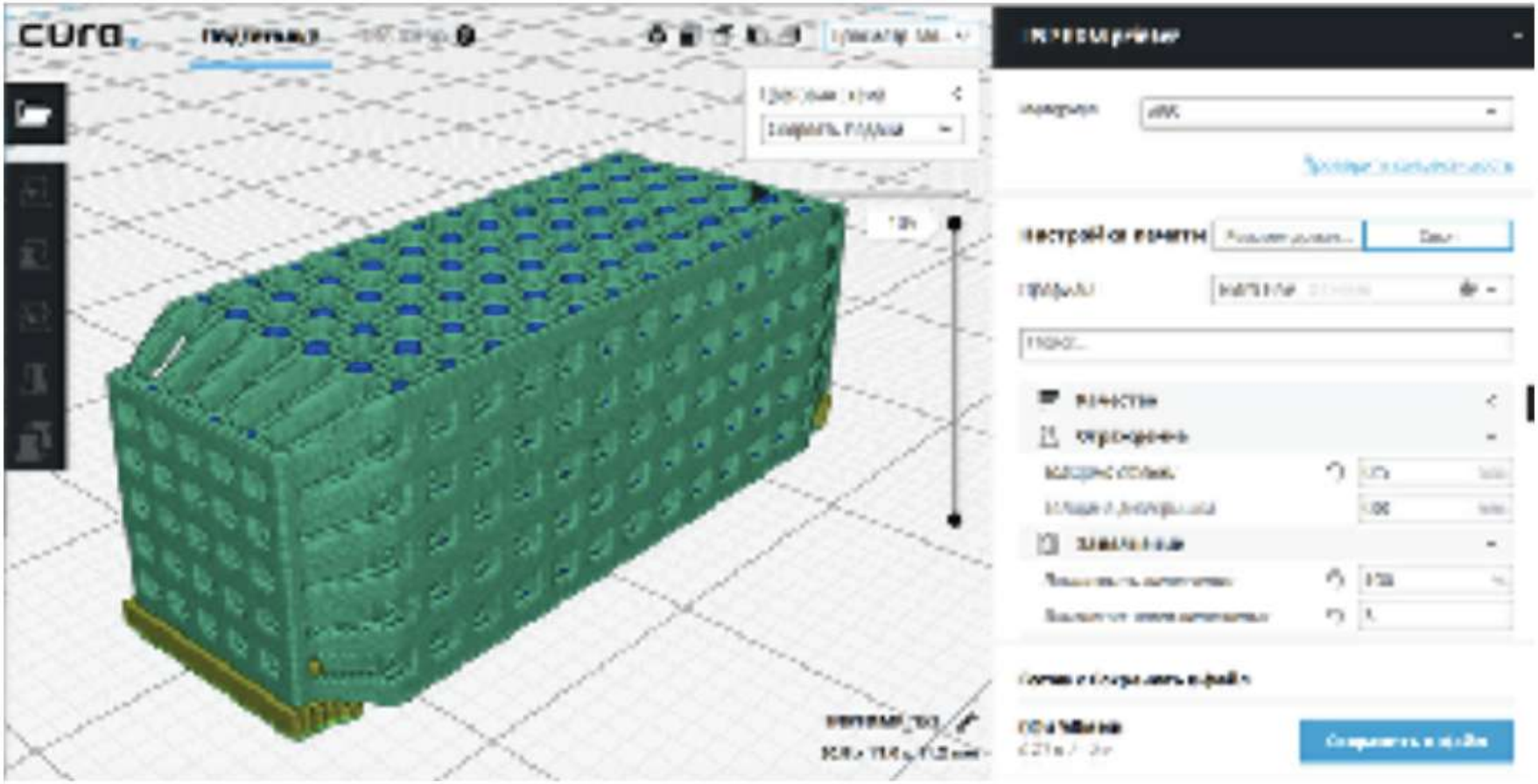
MADI IN BELARUS

Model of distributed 3D resistor



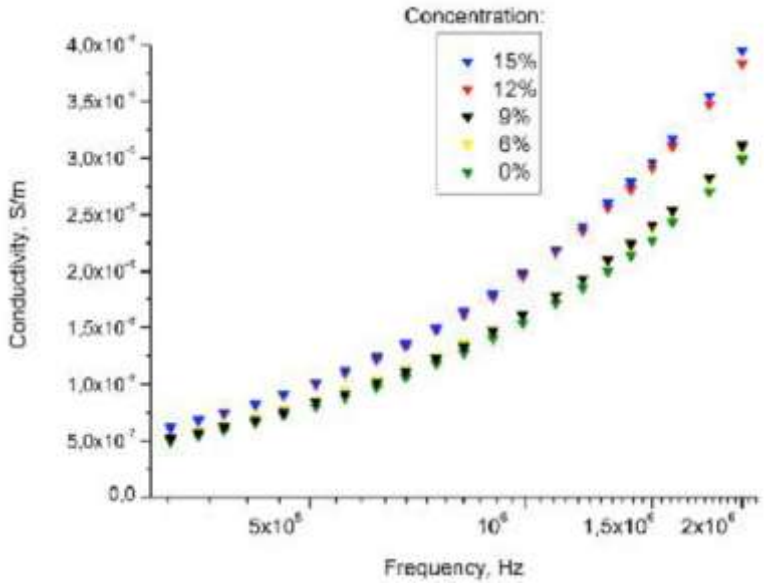
Blender is a professional grade, free 3D modeling software that is both comprehensive and completely open-source. Apart from the 3D modeling functionalities that are at the program's core, it also features modules dedicated to highly specialized tasks.

CURA slicing routine

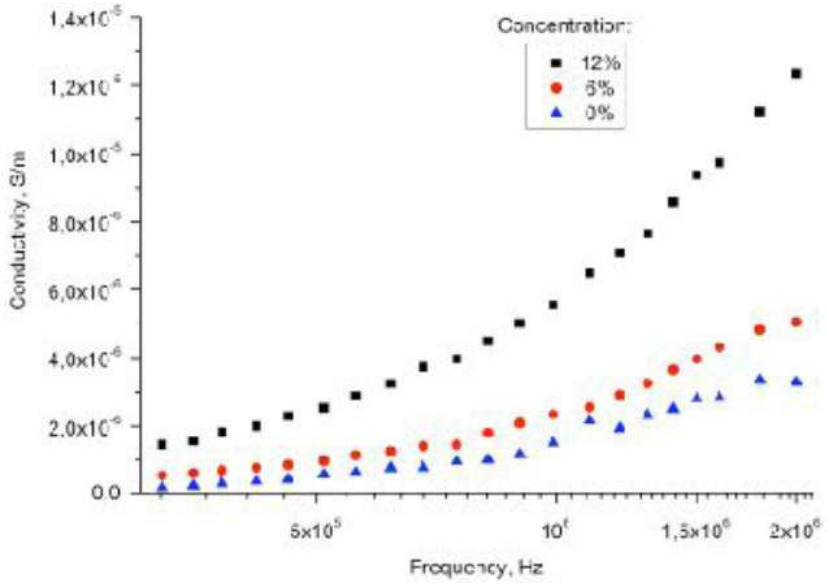


Conductivity measurements

Agilent LCR E4980A



Bulk materials



3D resistor prototypes

Theory

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Modeling the electrical properties of three-dimensional printed meshes with the theory of resistor lattices

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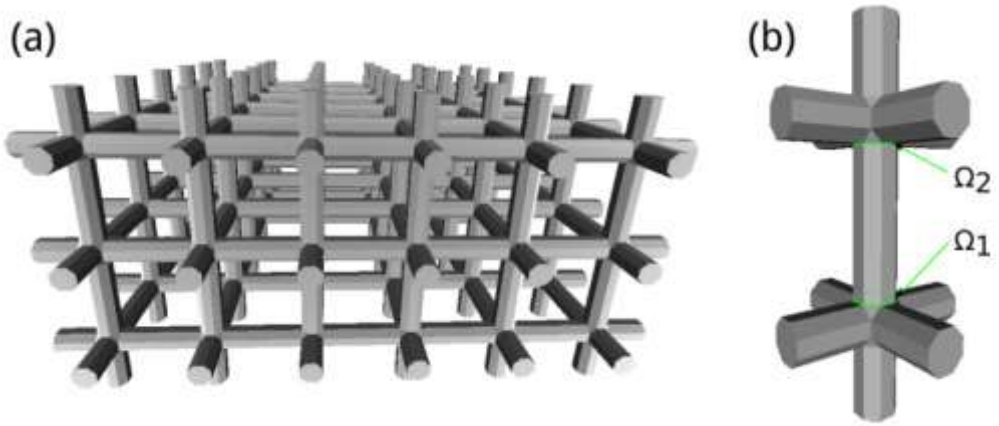
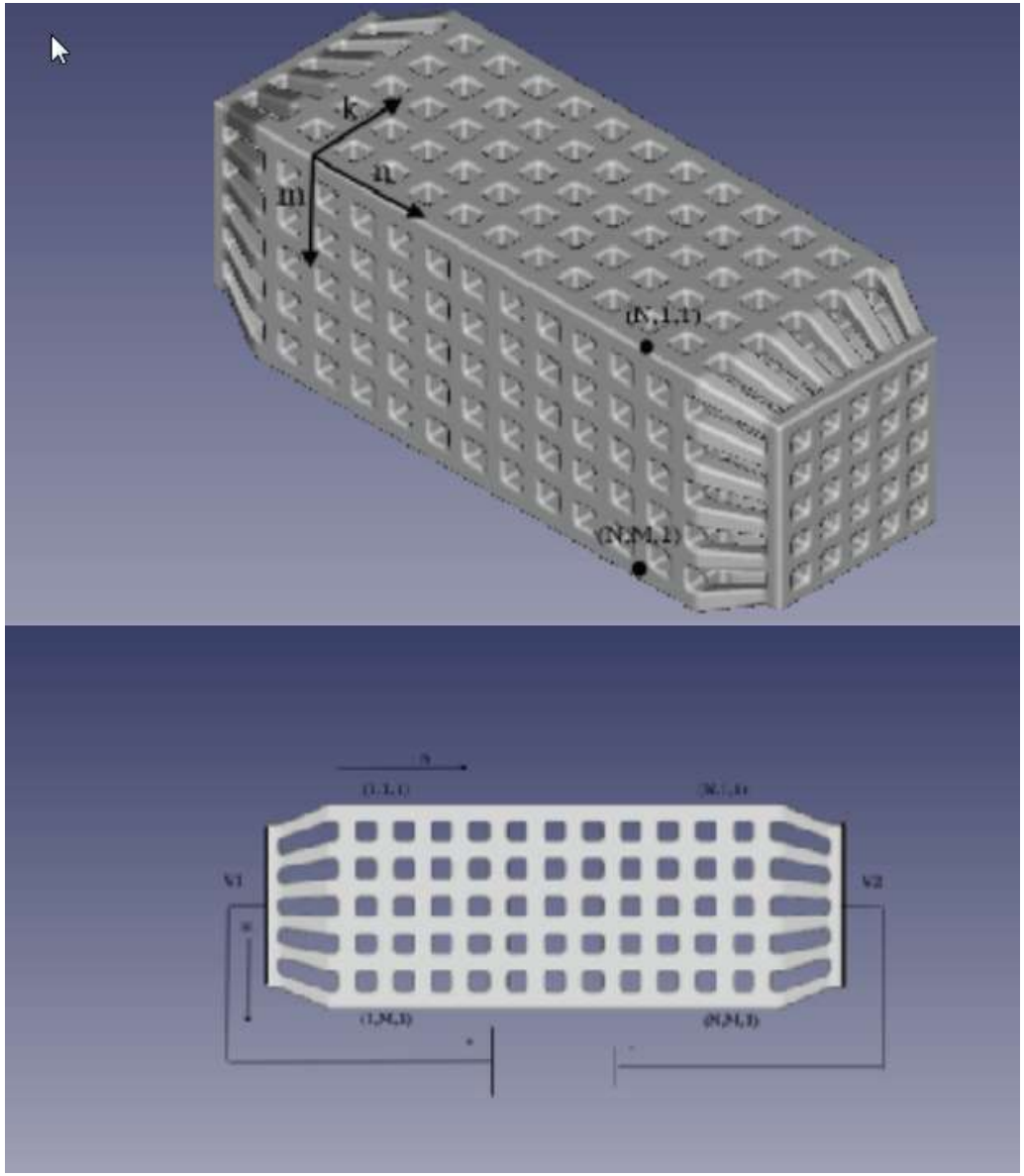


Calculation of the equivalent resistance



Conclusions

- 3D printing of thermoplastics by FDM technology can be used in electronics to produce supports and housings of various shapes providing heat transfer and EM shielding
- and also, probably, some passive components.

- We can produce filaments of thermoplastics filled with various nano objects, including nano tubes, carbon fibers and so on.

- Calculations of expected parameters for distributed 3D components demand sophisticated approaches

- Conductivity frequency dependence of nano-composites and absence of skin-effect can provide high frequency and pulsed applications

Thank you for attention