ζetamix

by NANOe

# Additive manufacturing of dielectric material for RF applications

# Our History :

## Advanced material provider

- Company specialized in the **ceramic** powder production
- **Industrial** scale production
- Focused on **innovation**
- **Zetamix** brand : metal and ceramic filament for FFF

**17**

Years
of experience

Batch from
100 kg to 1 ton

2 R&D
centers

20 people

# ZETAMIX

## A complete solution

**Materials :**

Alumina
Zirconia (white and black)
316L
H13
SiC
Porcelain
Zetamix Epsilon line

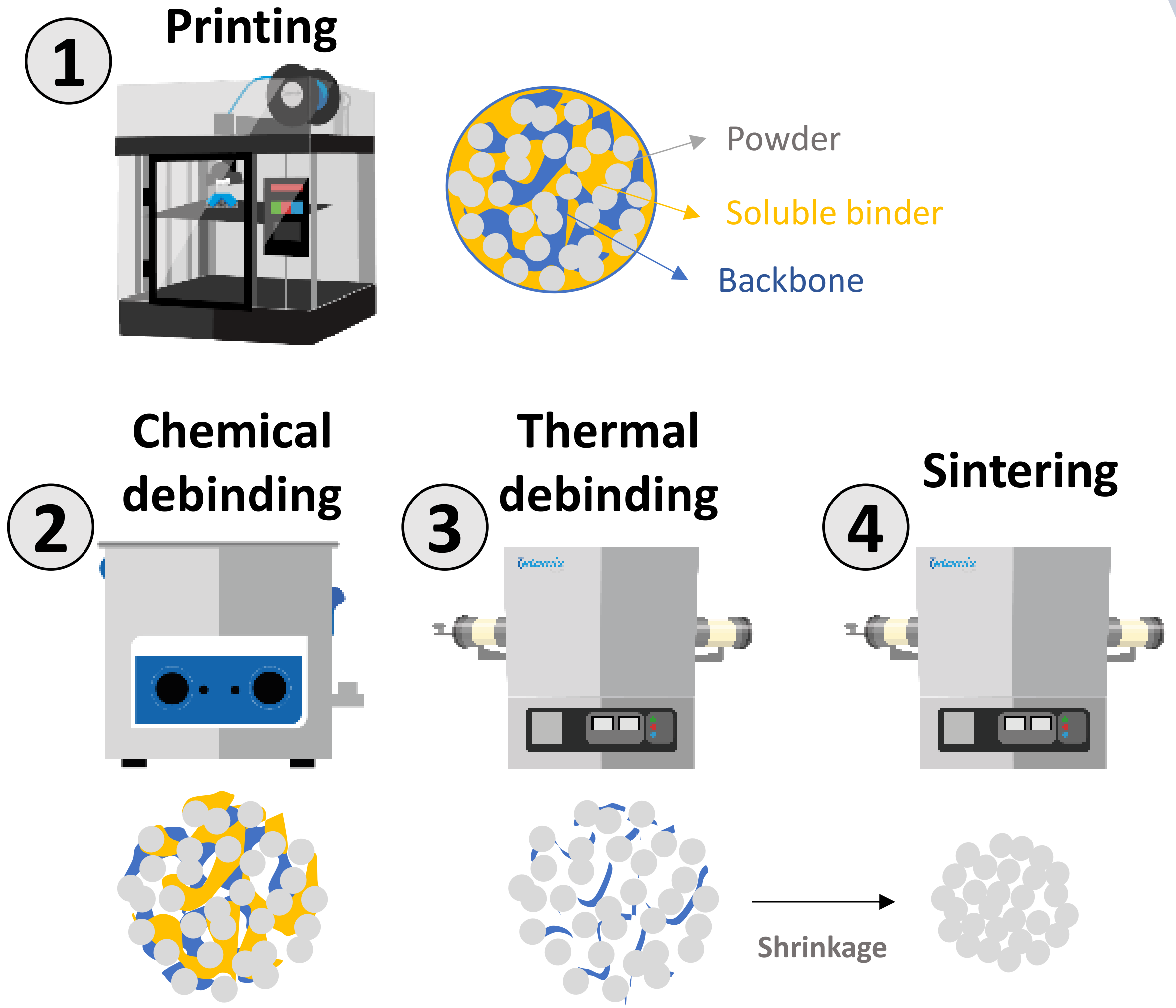

**Machines :**

3D Printer
Debinding kit
Sintering furnace

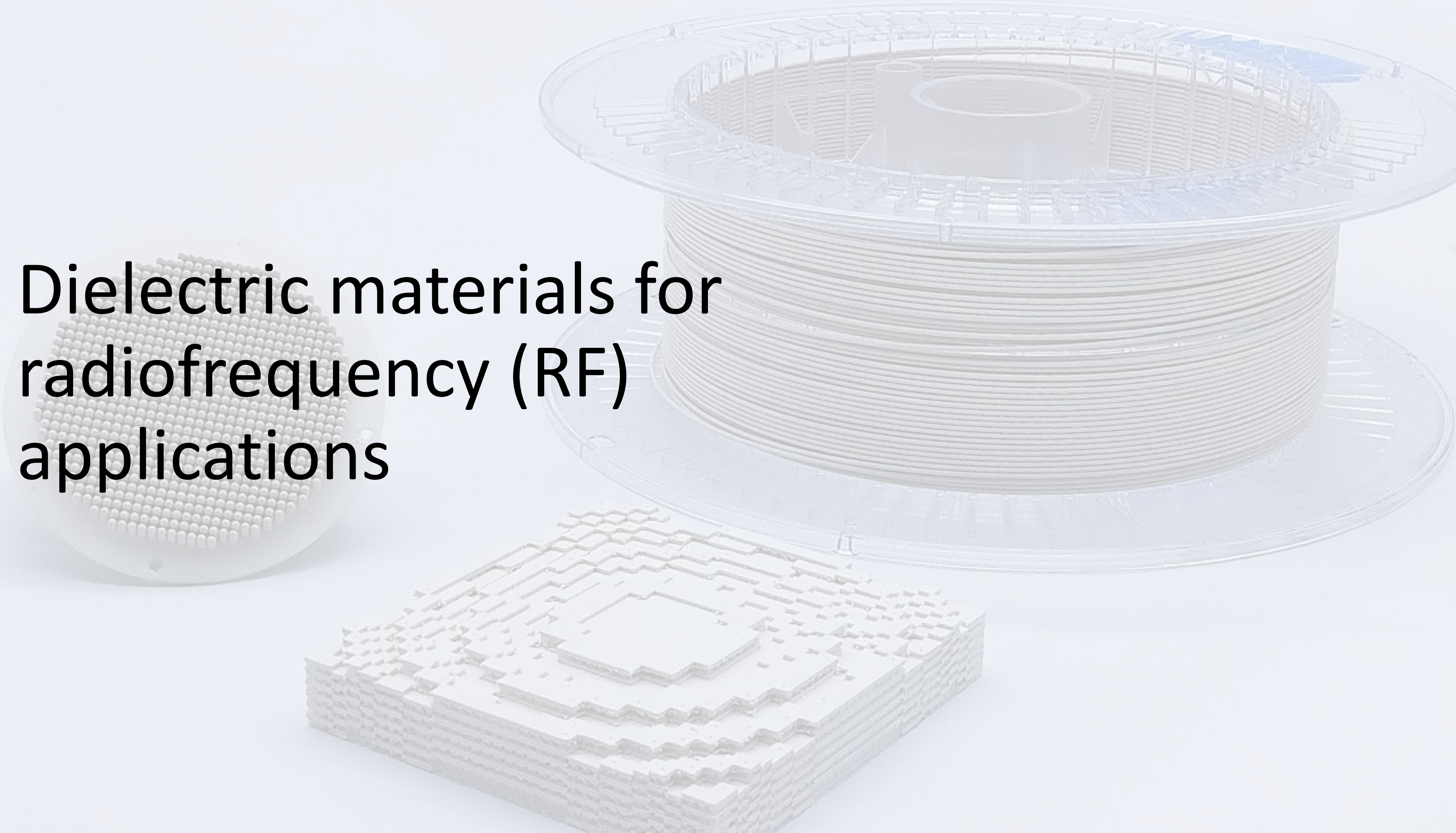
**15 k€**

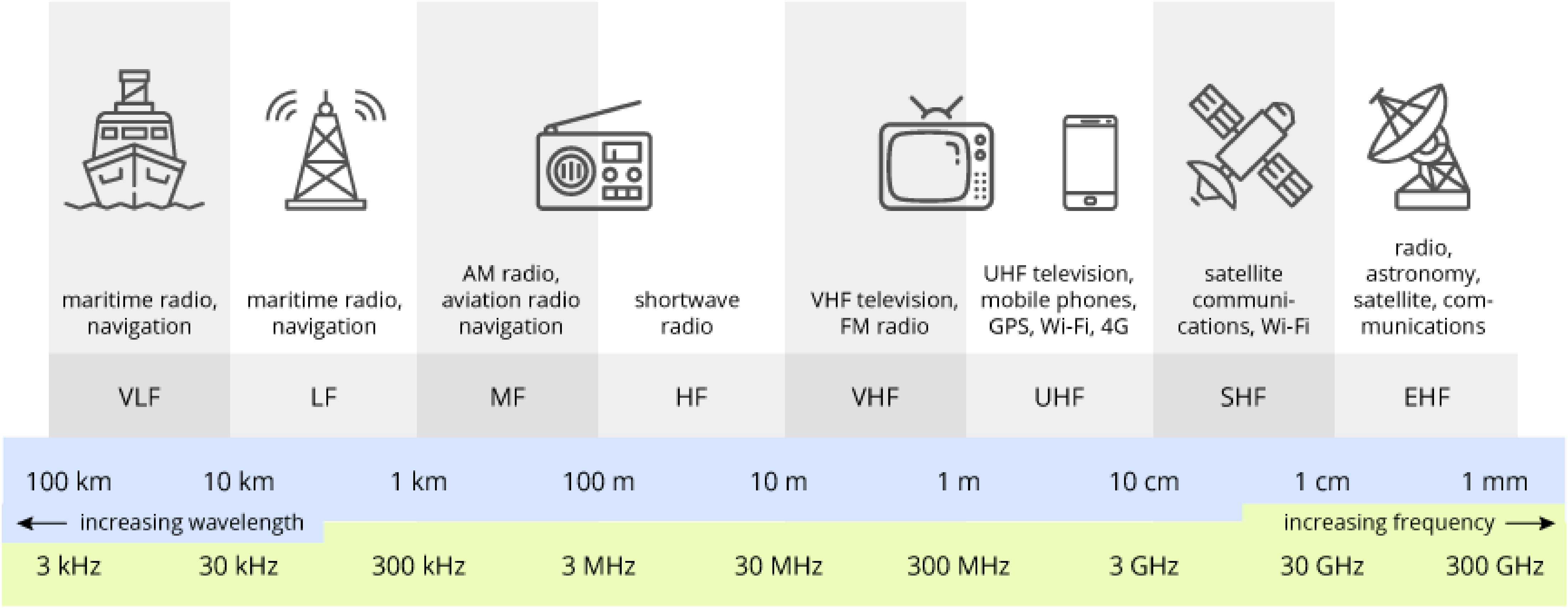

# ZETAMIX

## How it works




# Dielectric materials for radiofrequency (RF) applications





maritime radio, navigation
maritime radio, navigation
AM radio, aviation radio navigation
shortwave radio
VHF television, FM radio
UHF television, mobile phones, GPS, Wi-Fi, 4G
satellite communi-cations, Wi-Fi
radio, astronomy, satellite, com-munications
VLF
LF
MF
HF
VHF
UHF
SHF
EHF
100 km
10 km
1 km
100 m
10 m
1 m
10 cm
1 cm
1 mm
increasing wavelength
increasing frequency
3 kHz
30 kHz
300 kHz
3 MHz
30 MHz
300 MHz
3 GHz
30 GHz
300 GHz

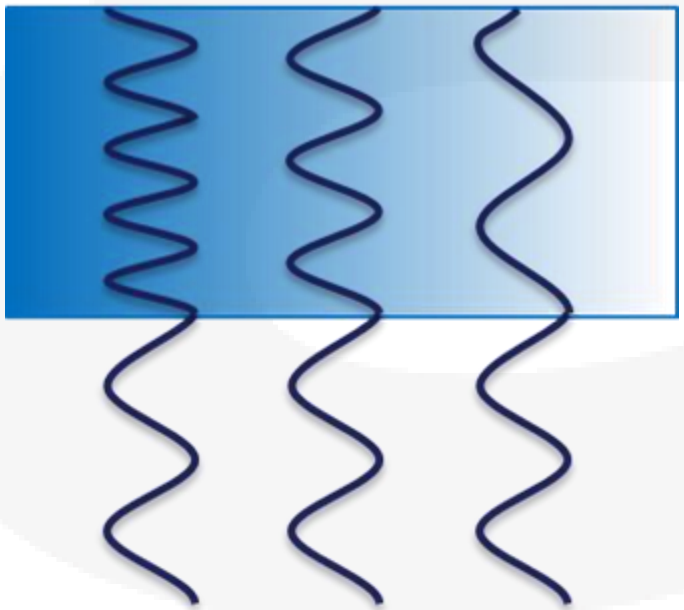
# What is a dielectric material?

A dielectric is an electrical insulator, which cannot conduct an electric current.

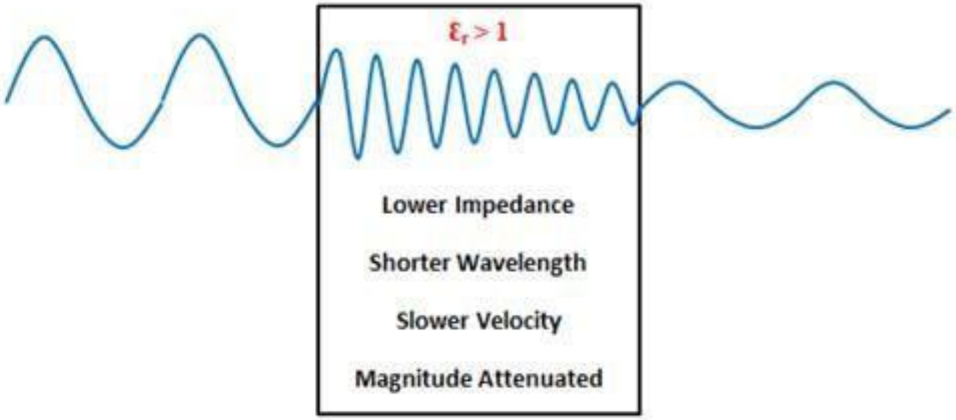
-> A dielectric material is characterized by its permittivity (or dielectric constant) $\varepsilon_r$ and its dissipation factor (or loss tangent) $\tan\delta$

# What is a dielectric material?

Electromagnetic wave inside a slab of dielectric




Low loss material

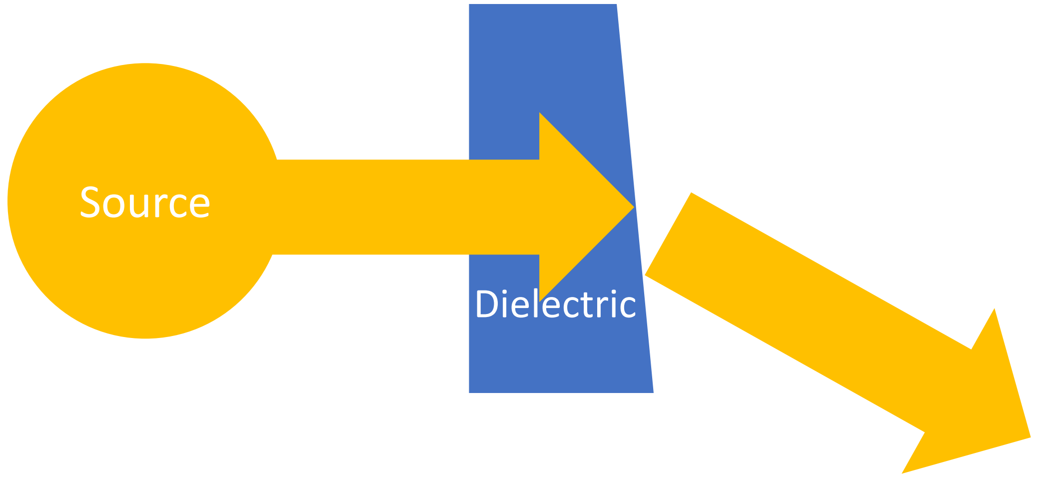



High loss material

# What is a dielectric material?

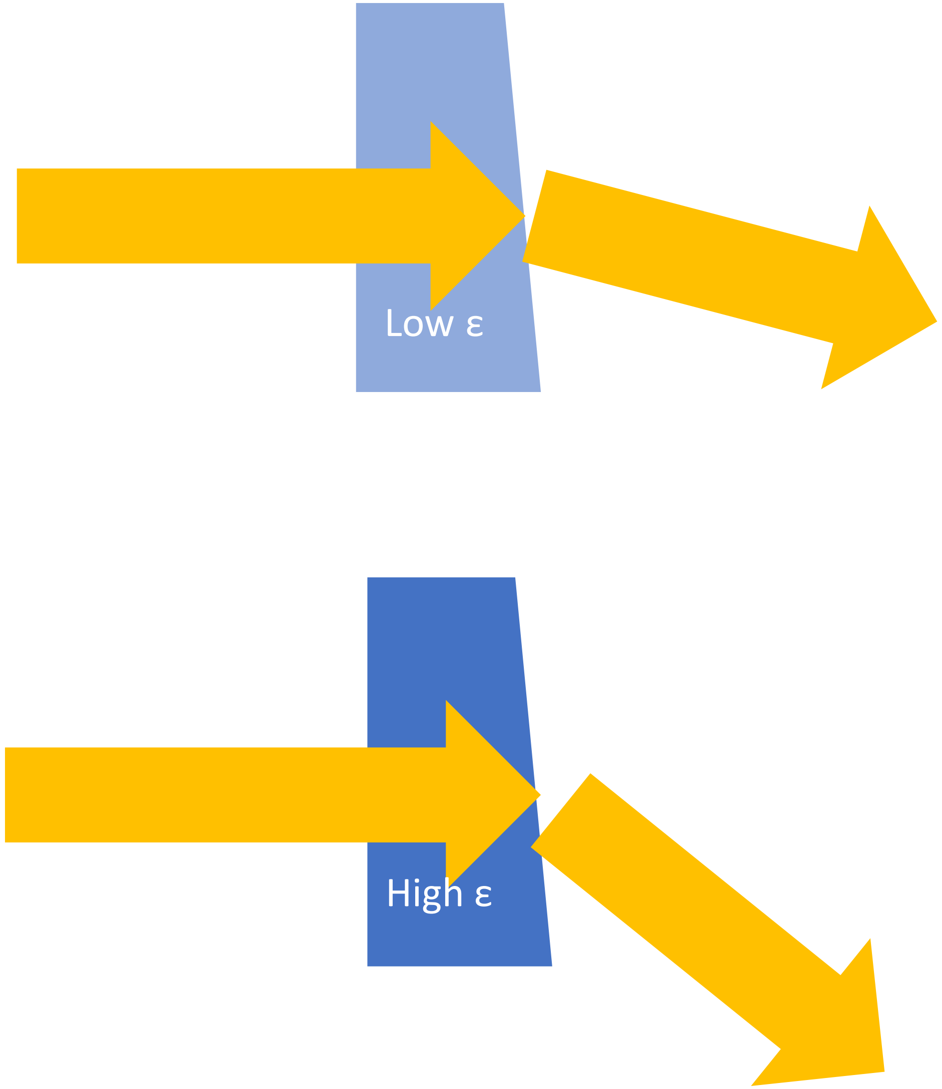
A material that will slow down the EM wave

A dielectric prism, lense… will deviate the EM wave from its initial course.



# What is a dielectric material?

The higher the permittivity is, the more the wave course will be deviated



# ZETAMIX LINE – Dielectric properties

**Ceramic** filaments

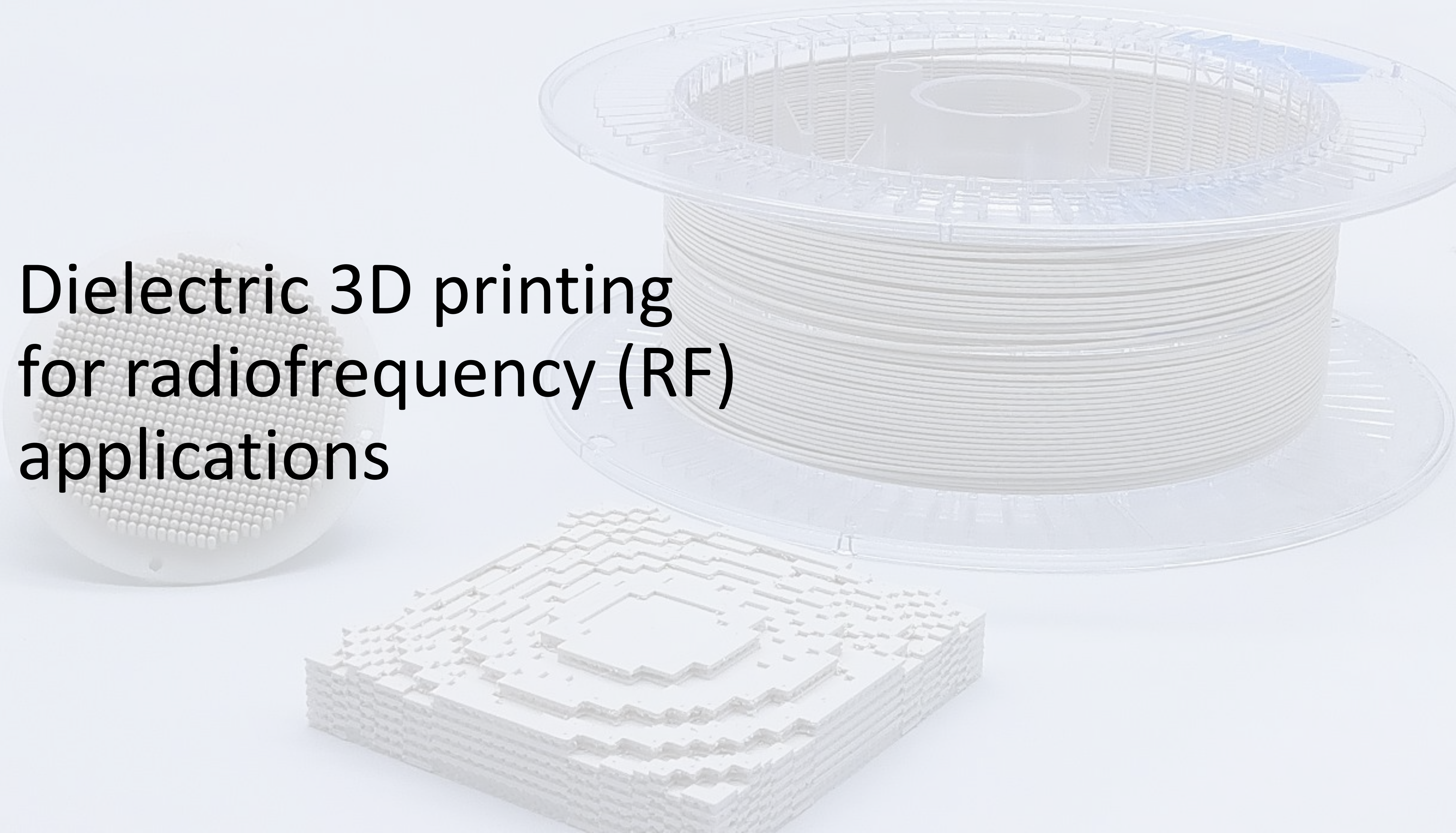

| Zetamix | Alumina | Zirconia | SiC | TiO2 |
|---|---|---|---|---|
| **Properties** | | | | |
| Dielectric constant (permittivity) | 9 (± 0.2) | 32 (± 0.5) | 15 (± 0.5) | 75 |
| Loss tangent | $< 1 \times 10^{-4}$ | $\approx 1 \times 10^{-3}$ | ≈ 0,3 | $\approx 1\text{-}3 \times 10^{-3}$ |

# ZETAMIX EPSILON LINE

**Ceramic filled** filaments – non sinterable

| Zetamix | Ɛ = 2.2 | Ɛ= 4.5 | Ɛ= 7.5 | Ɛ= 10 |
|---|---|---|---|---|
| **Properties** | | | | |
| Dielectric constant (permittivity) | 2.2 (± 0.2) | 4.5 (± 0.5) | 7.5 (± 0.5) | 10 (± 0.5) |
| Loss tangent | $< 1x10^{-3}$ | $\approx 1x10^{-3}$ | $\approx 1x10^{-3}$ | $\approx 1x10^{-3}$ |
| HDT (°C @0,45MPa) | 110 | 110 | 110 | 110 |
| Tensile strengh | | | 23 MPa | |

# Dielectric 3D printing for radiofrequency (RF) applications

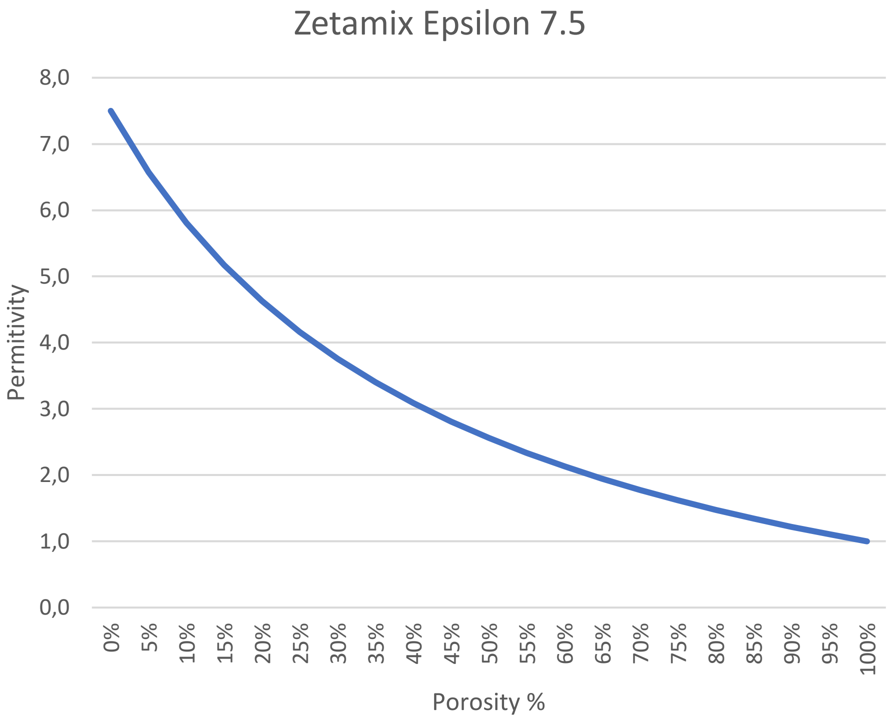


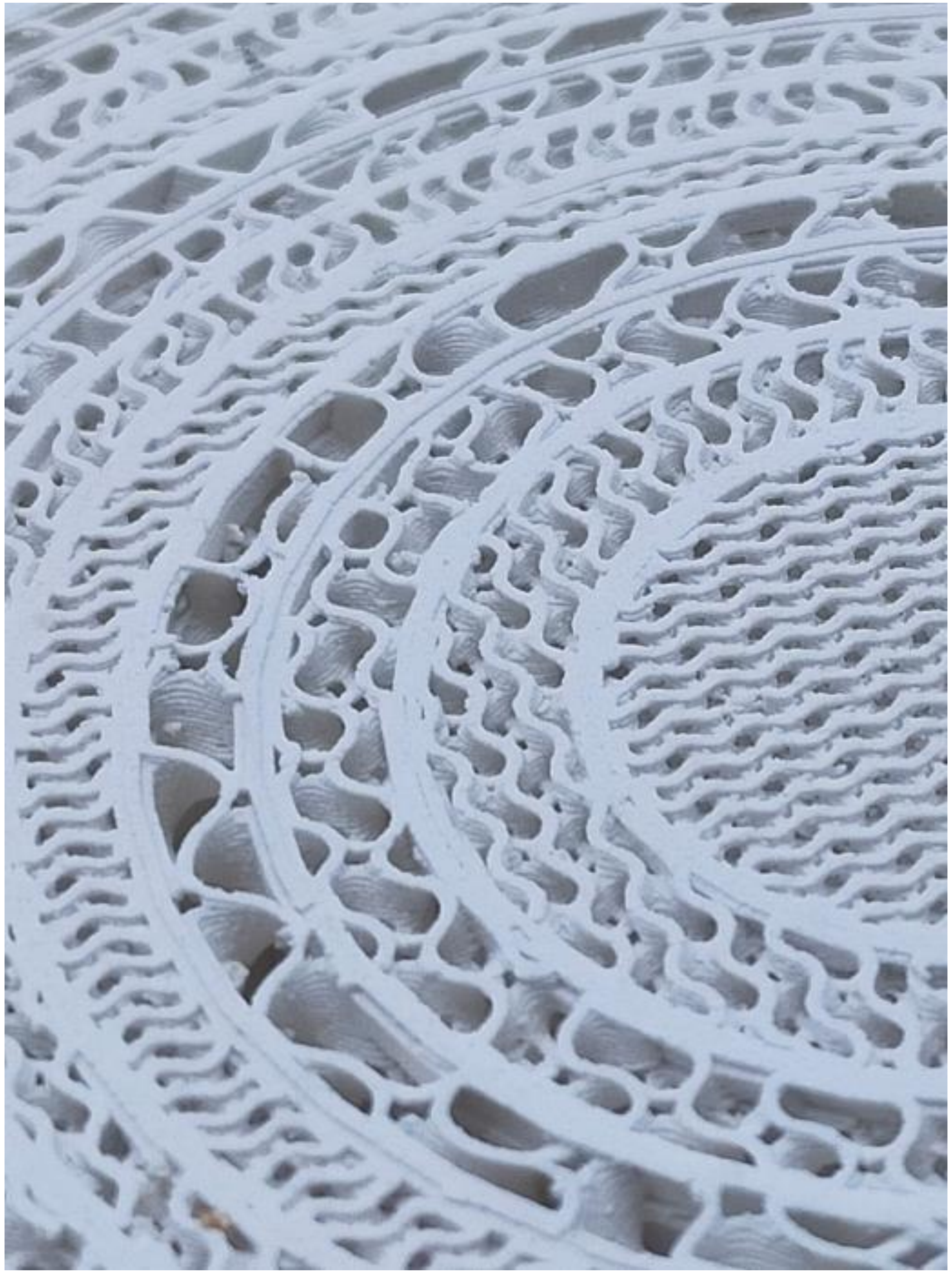
# Why using 3D printing for RF?

1- to produce complexe shapes, small volume production…

# Why using 3D printing for RF?

## 2- To tune permittivity through variations on infill



# Why using 3D printing for RF?

3- to produce metamaterial and metasurfaces, structured below the operating wavelength

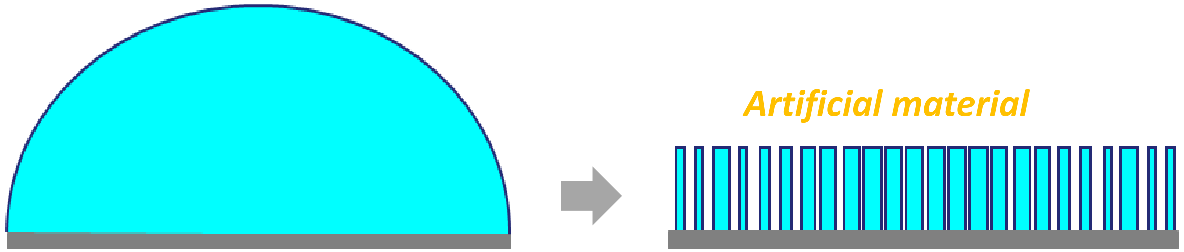
**Example of an RF component**

**Bulk dielectric lens**

**Structured dielectric lens**

**Low profile and efficient**

*Artificial material*



*Thousands of pillars from hundreds µm to several mm*


Material : Rexolite
Process : Machining

Material : ABS
Process : **FDM 3D-printing**

# USE CASES:

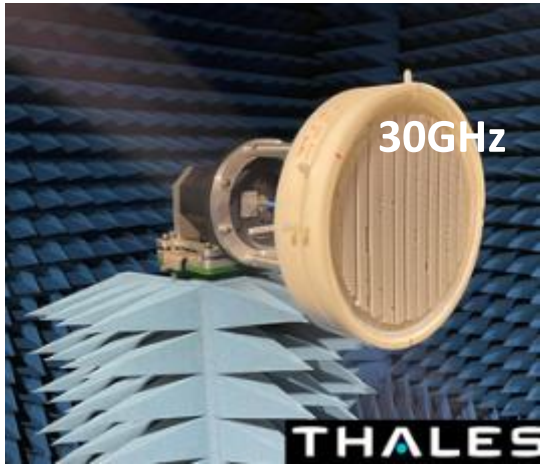
# DEFLECTOR

- 28 and 46 cm metasurface Material: Zetamix Epsilon 7,5

  Potential applications: low-cost antennas for

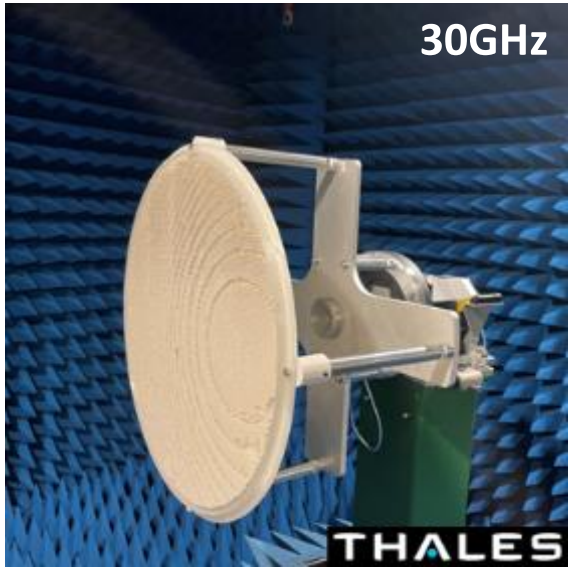
  - **Point-to-point, Point-to-Multipoint communication**
  - **Satellite communication on moving platforms**

**Low-profile 2D-beam-steering antenna**





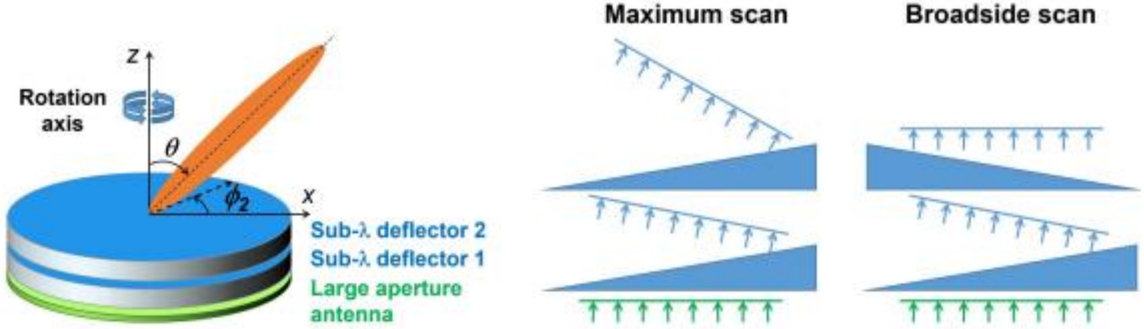
**Directive lens antenna**




https://ieeexplore.ieee.org/document/9924439
https://hal.science/hal-04630858/

# DEFLECTOR

Two deflectors Risley scanning system : need the printing of **very fine cells** and a **tuning of the dielectric permittivity** at the cell scale



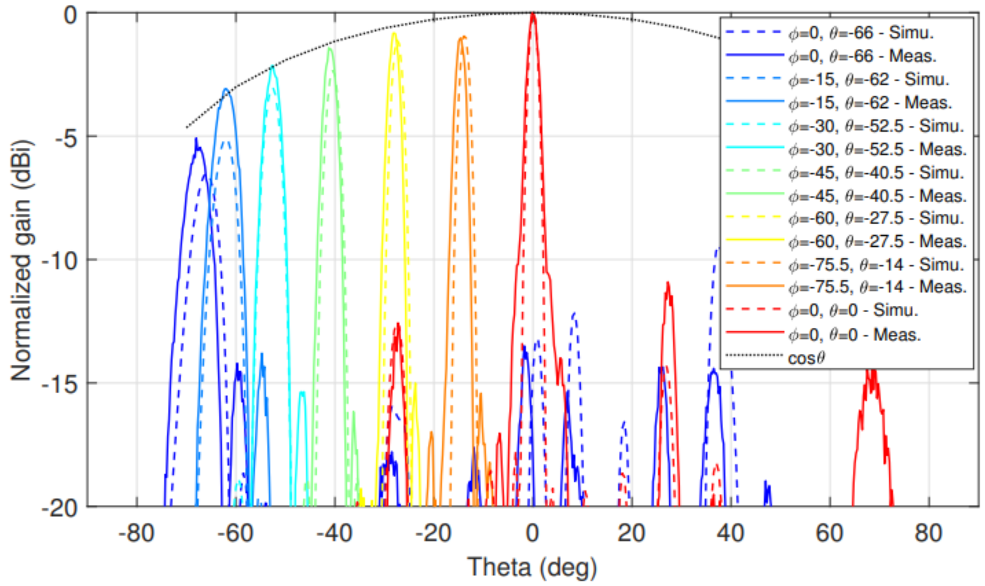
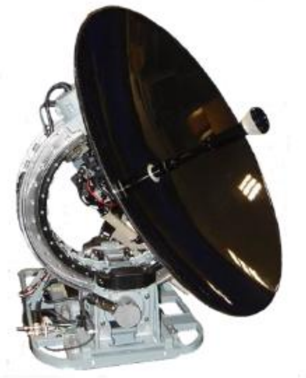



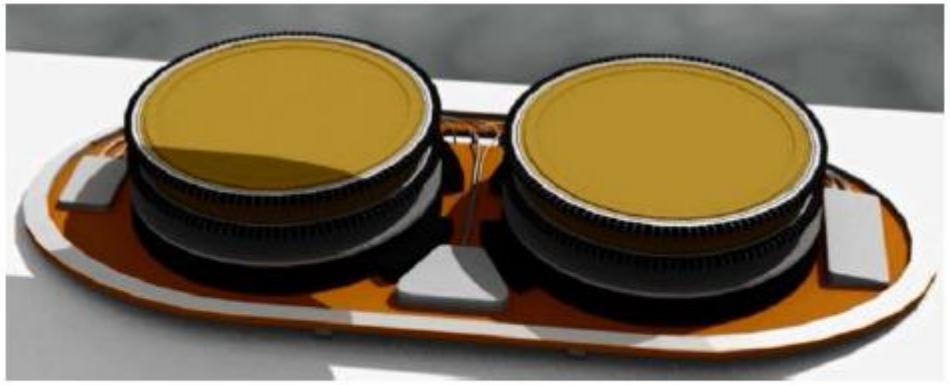

Fig. 6. Normalized gain in simulation (dashed line) and measurement (solid line) at 29 GHz for seven different steered angles.

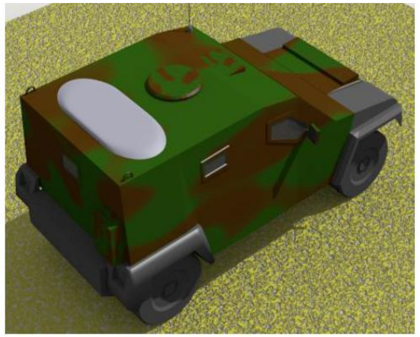
**Low-Profile Highly Directive 2D-Beam-Steering Antenna in Ka-band with 3D-printed All-dielectric Sub-wavelength Deflectors**

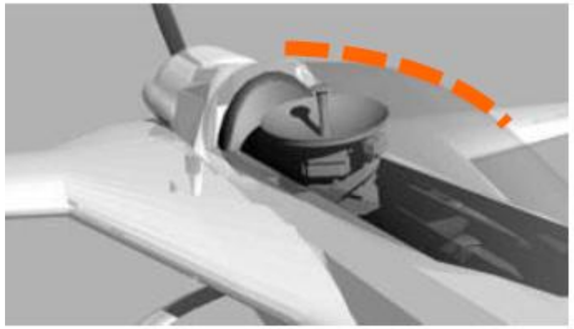
Thi Quynh Van Hoang, Matthieu Bertrand, Erika Vandelle, Brigitte Loiseaux

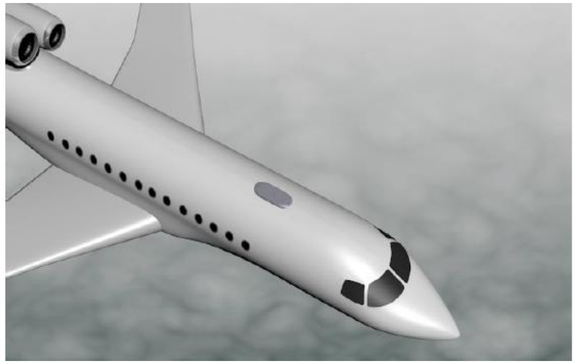
# DEFLECTOR FOR SATCOM



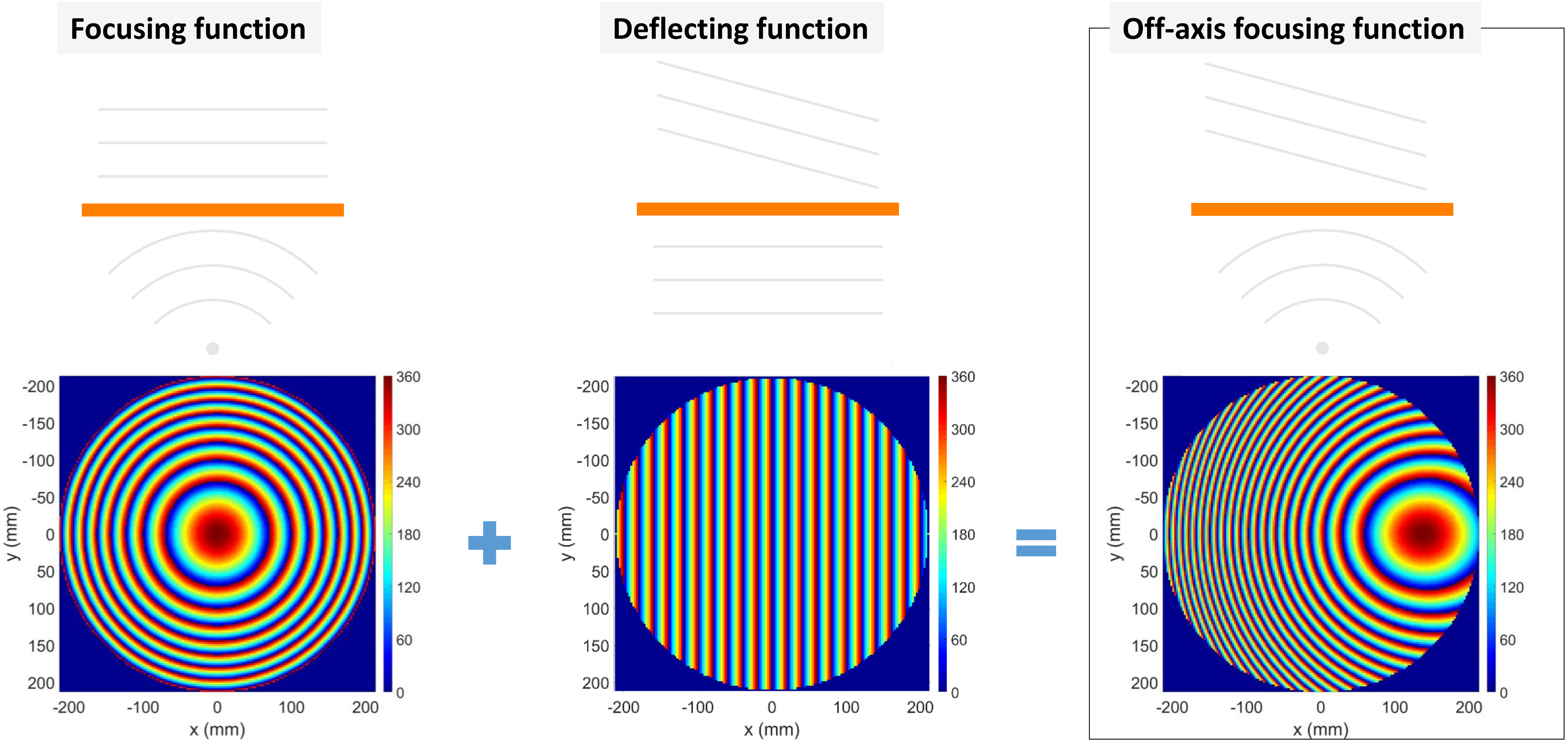






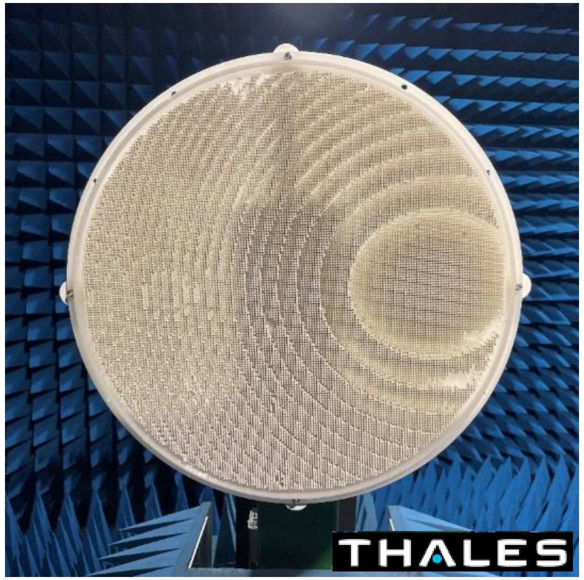


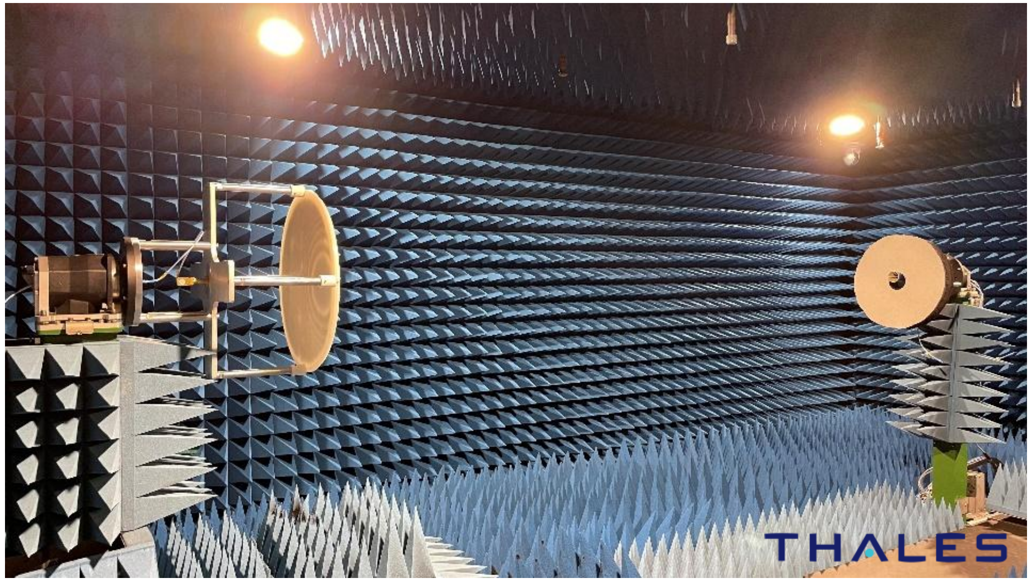
# Off-axis lens design



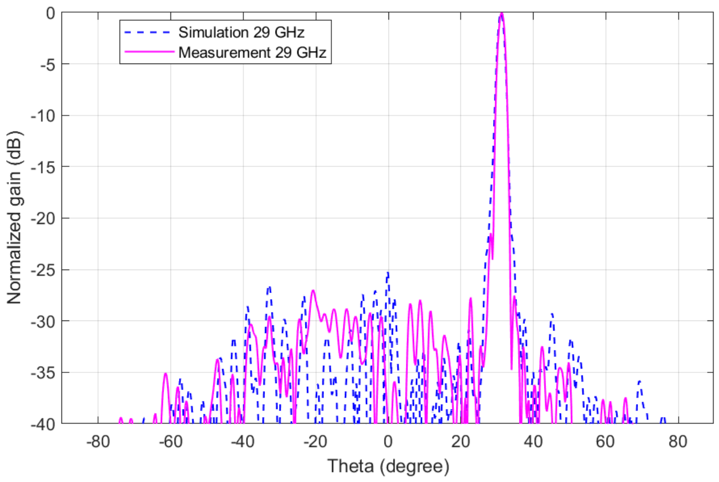

EuCAP 2023

# Of axis Lens

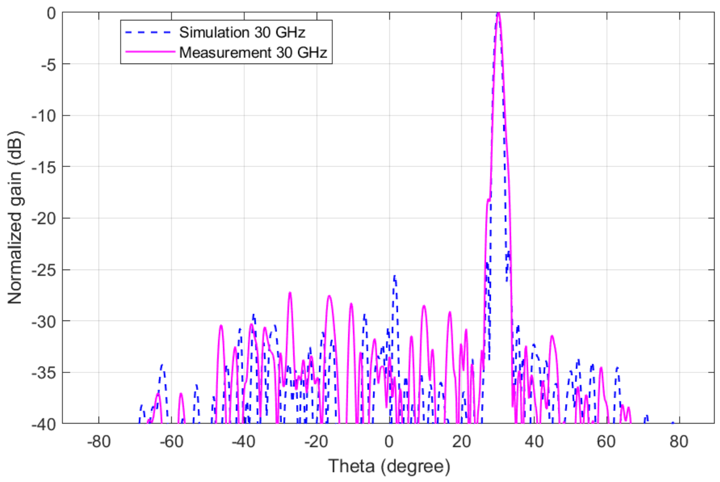



**29 GHz**




**30 GHz**



# DIELECTRIC RESONNATOR ANTENNA

- Variable infill allowing an adjustable permittivity
- Material: Zetamix zirconia
- Application in satellite communifaction (uplink/downling in the same antenna)

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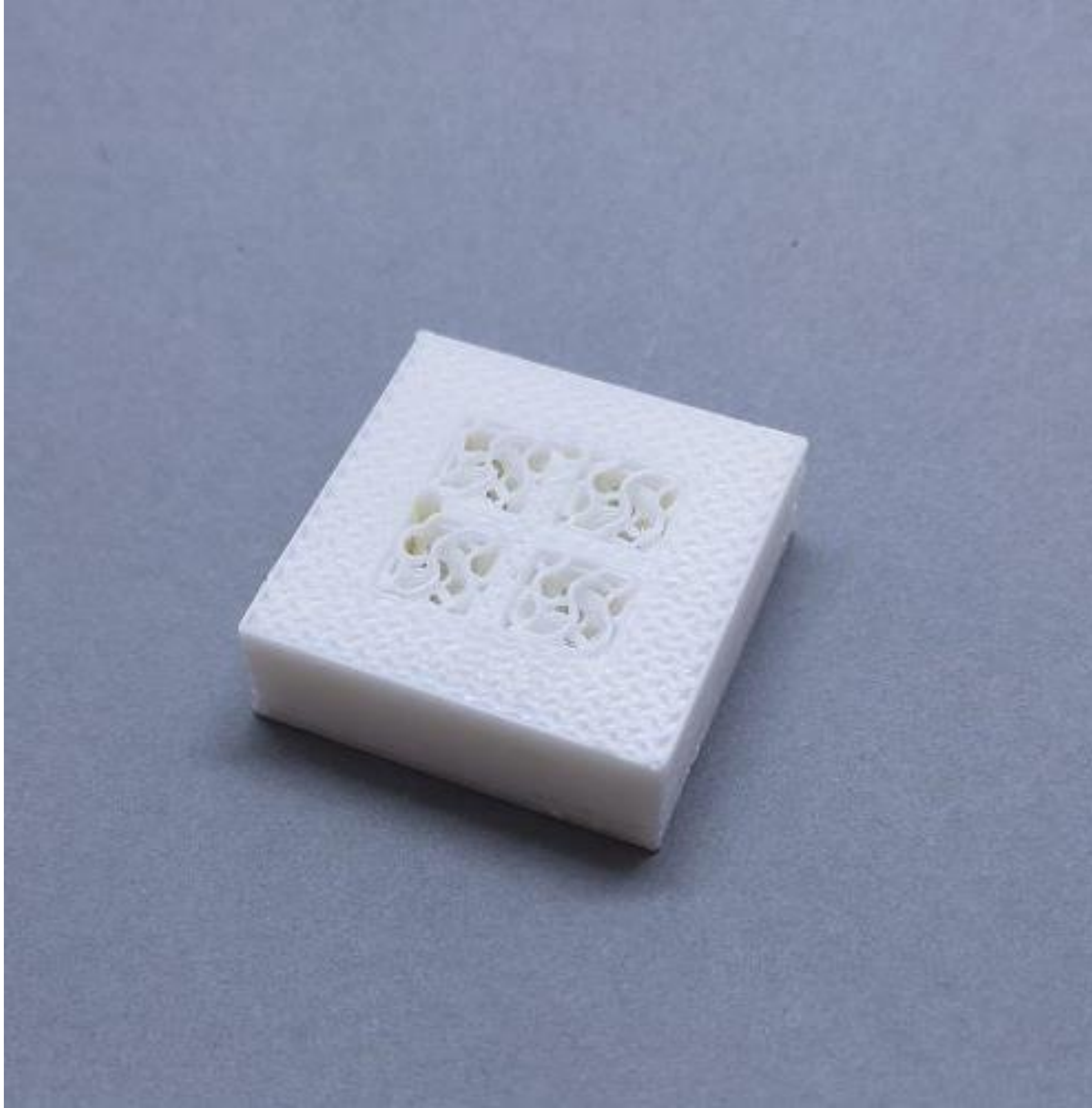
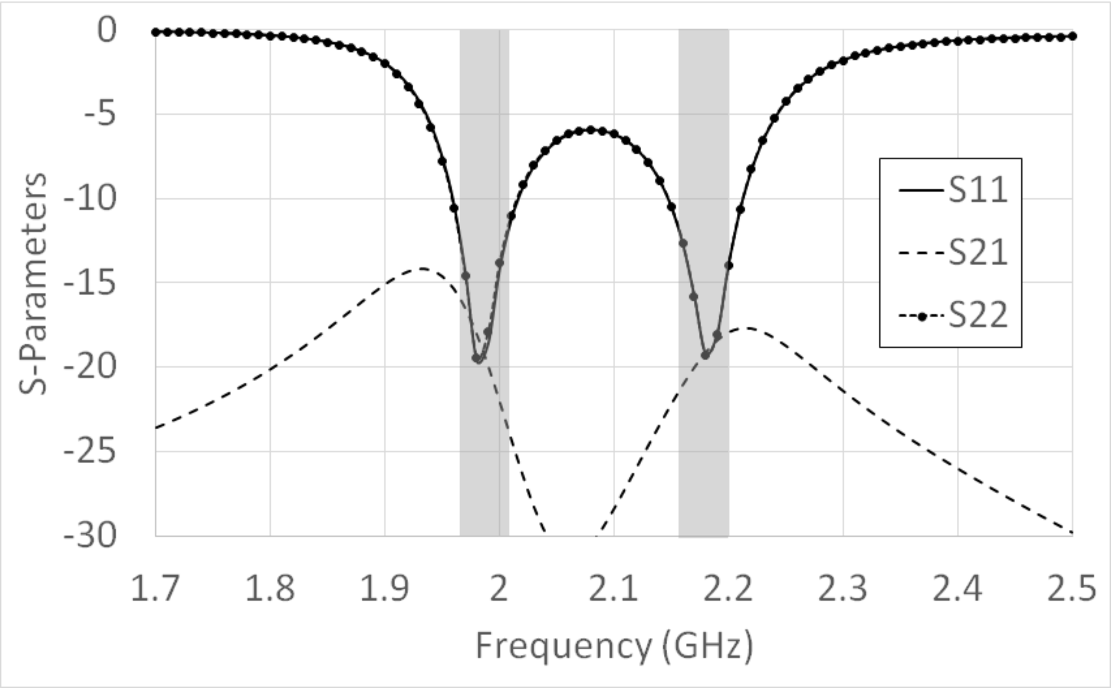
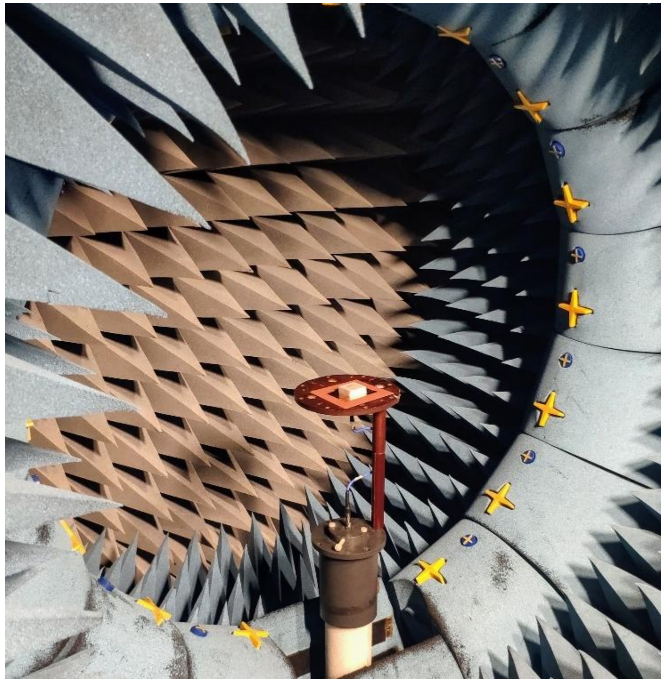
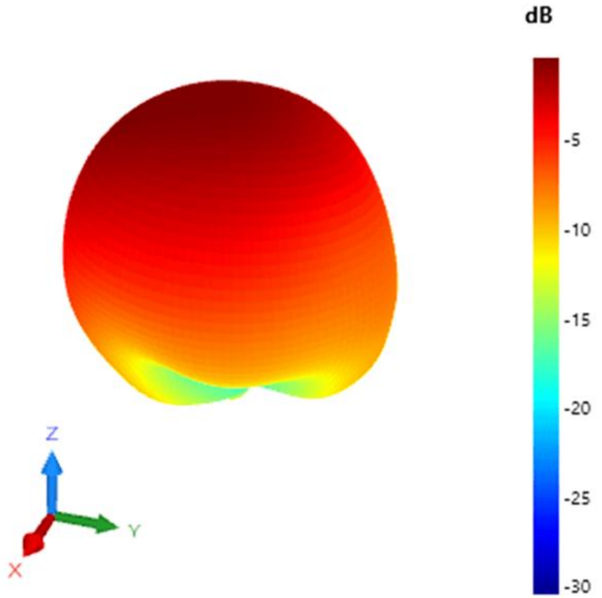
https://ieeexplore.ieee.org/document/9768899



# DIELECTRIC RESONNATOR ANTENNA





# DIELECTRIC RESONNATOR ANTENNA FOR SATELLITE CUBSAT & IOT

# RF REFLECTARRAY

- Metamaterial
- Material: Zetamix Epsilon 2.2 & 7.5

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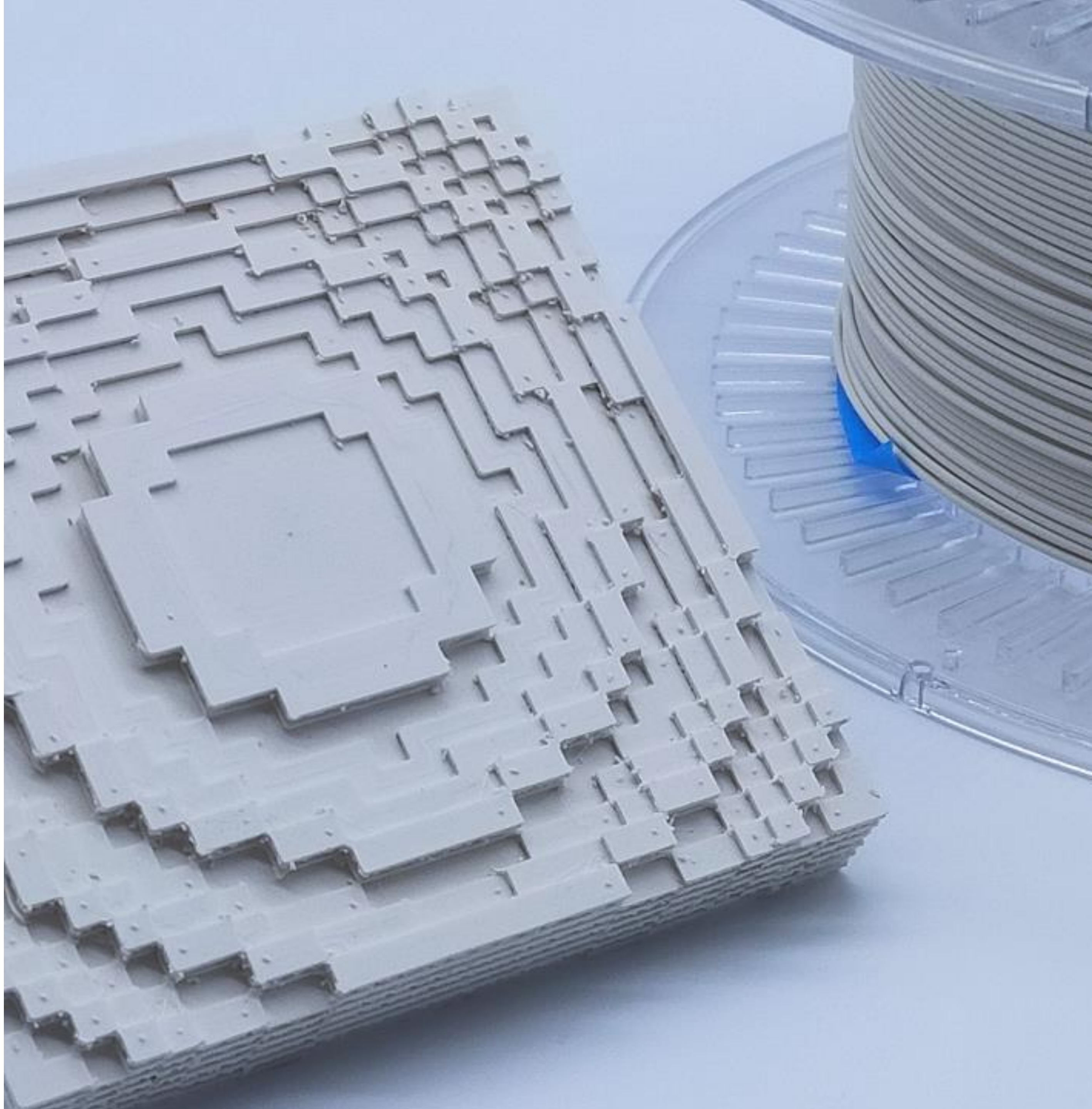
« 3D Printed Dual Material Reflectarray Antenna » publication in process



# PATCH ANTENNA

- Multimaterial 3D printing
- Material: Zetamix Epsilon 7.5 + silver ink
- Full 3D printed fonctional antenna

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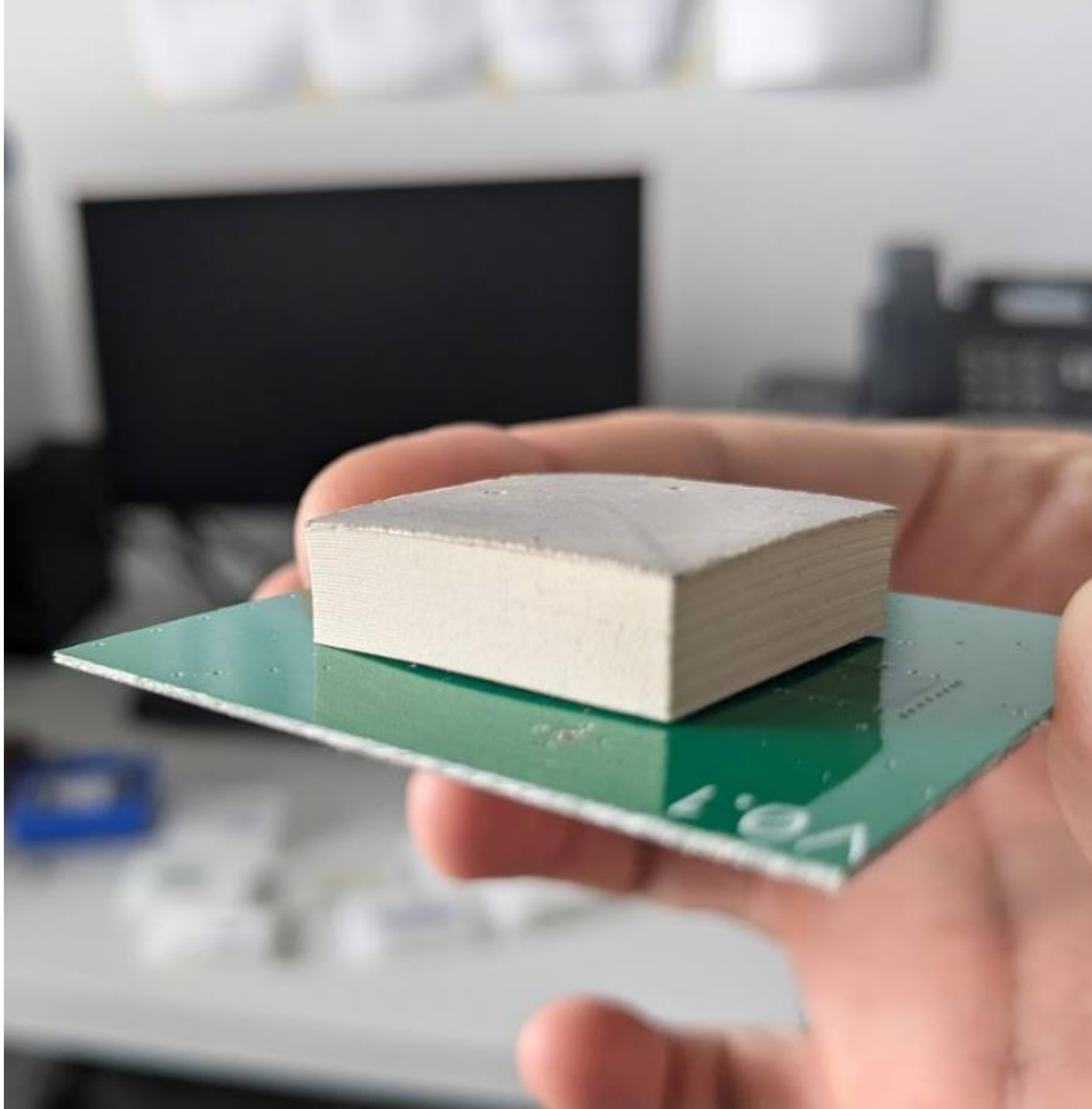
Neotech AMT
Advanced Manufacturing Technologies for 3D Printed Electronics

https://hal.science/hal-04630921/
Design of Antennas Using Additive Technology With Surface Metallization – publication in process



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