HYMAG'IN
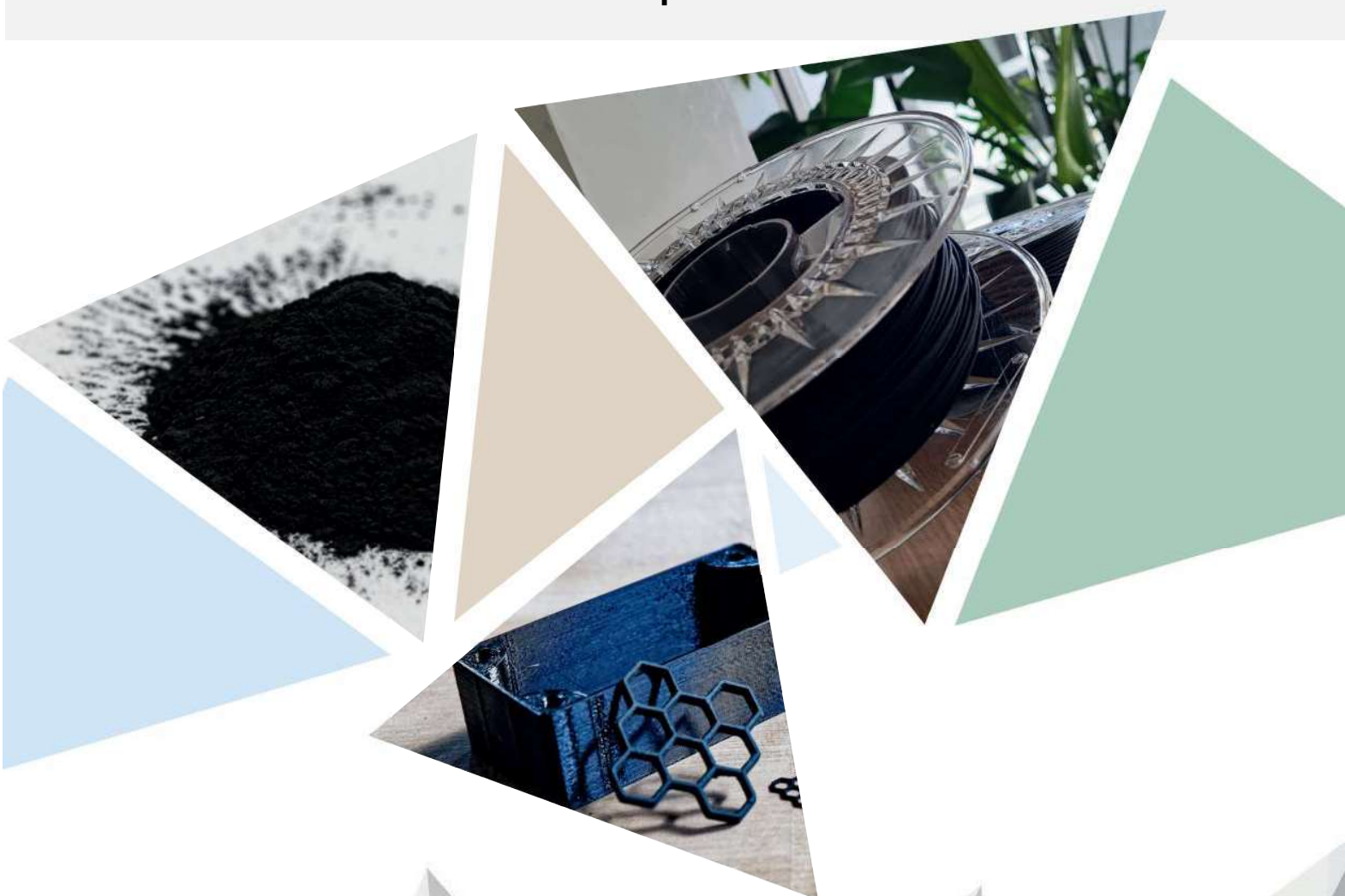
Product catalogue

Magnetic filaments and ferrite powders

Discover HYMAG'IN

HYMAG'IN produces and sells several ranges of **innovative ferrite-based magnetic materials**. **The products are ultra-fine powders or semi-finished products for additive manufacturing**, such as magnetic filaments. HYMAG'IN products are aimed at aerospace, defense, automotive and telecom markets.

Ferrites are widely used in electronic systems. They are essential magnetic materials for passive components and solutions for electromagnetic compatibility (EMC). However, ferrite users face many challenges:

- **miniaturize to reduce weight and volume**
- **reduce their environmental impact and energy consumption**
- **secure their supply chains**

HYMAG'IN provides a solution to these needs by producing ferrites 100 times smaller, **using a unique, sustainable and low-energy technology based in Europe**.

FILAMAG™ is a range of filaments designed for the addictive manufacturing of absorbing microwave products.

NANOMAG is designed for the manufacture of radio frequency absorbing materials for EMC. It can also be used to produce passive components for inductors, transformers and filters in the kHz - MHz range.
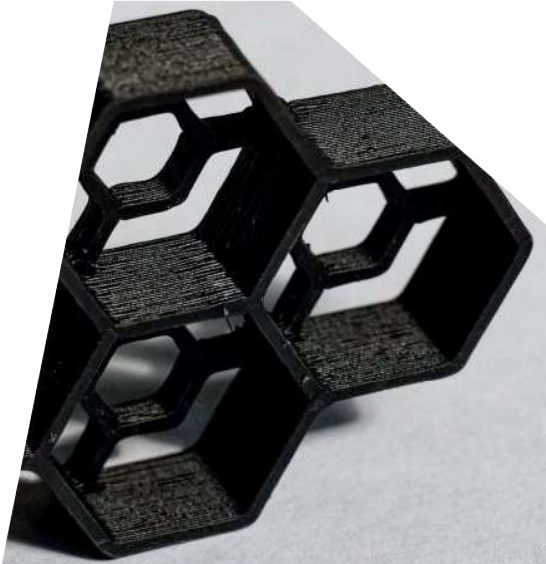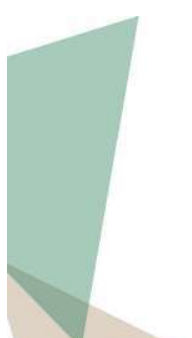
Table of contents
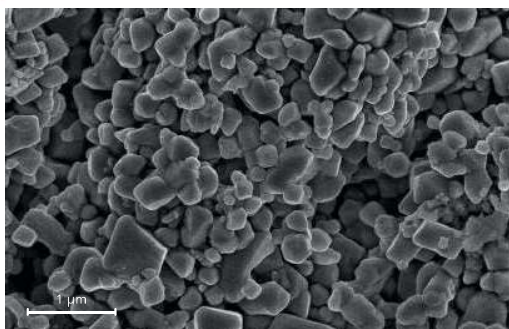
NANOMAG-MnZn
| Features

SEM Picture

NANOMAG-MnZn is a **Manganese-Zinc (Mn,Zn)Fe$_2$O$_4$ ferrite powder**.

The quality of NANOMAG products is characterised by electron microscopy (SEM-EDS) and X-ray diffraction (XRD).

Density		5 g/cm³
Purity		99.99 %
Laser granulometry		2 µm (avg)
Crystal size (SEM)	D10	100 nm
	D50	200 nm
	D90	400 nm
Curie temperature		330 °C
Saturation magnetisation		78 emu/g
Use frequencies		from 100 MHz to 5 GHz

NANOMAG-MnZn powder is **easily incorporated into all types of polymers and silicones thanks to its ultrafine size**. Therefore, sheets, gaskets and coatings made from NANOMAG-MnZn-filled composites are excellent EMC absorbers at frequencies ranging from 100 MHz to 5 GHz.

NANOMAG-MnZn can also be sintered to produce dense, low-loss ferrite products for energy conversion or signal filtering in the kHz - MHz range.

Why choose NANOMAG-MnZn?

ABSORBERS IN METAL CASINGS

Adhesive absorbing sheets, based on NANOMAG-MnZn dispersed in silicone, are positioned inside the metal casings protecting the electronic board components.
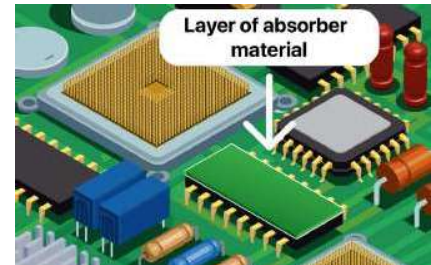
These sheets **absorb energy to attenuate interference due to wave reflection within the resonant cavity**.
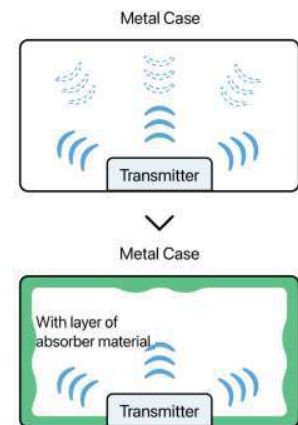
EMC ABSORBERS ON COMPONENTS

Composite absorber plates loaded with NANOMAG-MnZn are layed on the radiating component.
In EMC, these plates solve the problem of RF electromagnetic radiation directly on the problematic component.

With their high magnetic absorption losses (μ") and magnetic field storage capacity (μ'), these plates **reduce the noise caused by the radiating component**.
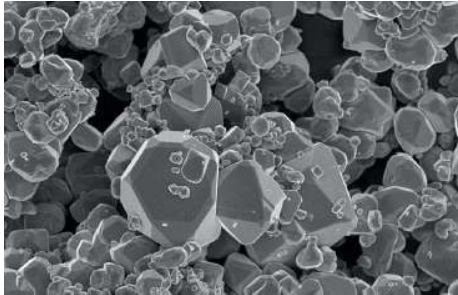
TOROIDS FOR POWER ELECTRONICS

Sintering NANOMAG-MnZn enables to realise magnetic components used in inductors, transformers and converters.

These components **modify the voltage and current values of power supply circuits at frequencies ranging from kHz to MHz**.
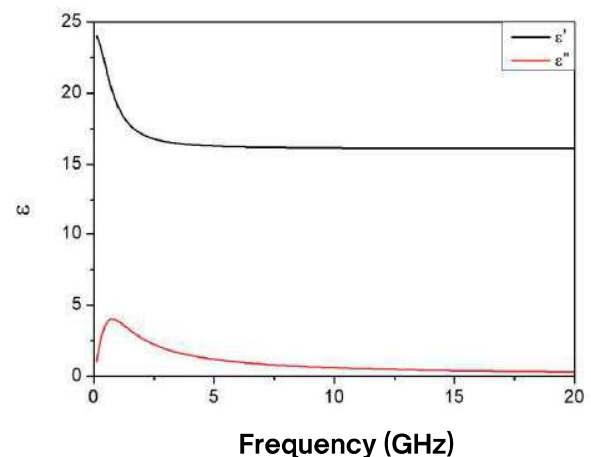
NANOMAG-Fe
|Features

SEM Picture

NANOMAG-Fe is a powder of iron oxide Fe_3O_4.
The quality of NANOMAG products is characterised by electron microscopy (SEM-EDS) and X-ray diffraction (XRD).

Density		5 g/cm³
Purity		99.99 %
Laser granulometry		4,6 µm (avg)
Crystal size (SEM)	D10	240 nm
	D50	700 nm
	D90	1 600 nm
Curie temperature		580 °C
Saturation magnetisation		86 emu/g
Use frequencies		from 1 to 20 GHz
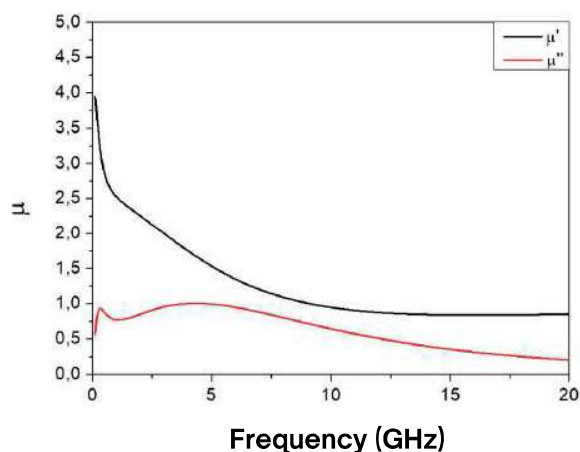
Permeability and permittivity of a composite filled at 70%wt (measured)

Why choose NANOMAG-Fe?

NANOMAG-Fe powder is **easily incorporated into all types of polymers and silicones** to produce electromagnetic absorbing composite materials, such as thin, flexible, easily machinable sheets. These composites can also be used to make shielding gaskets, absorbing foams, magnetic paints and other products.

Below are examples of EMC use cases after shaping NANOMAG-Fe.

ABSORBERS IN METAL CASINGS

Adhesive absorbing sheets, based on NANOMAG-Fe dispersed in silicone, are positioned inside the metal casings protecting the electronic board components.

These sheets **absorb energy to attenuate interference due to wave reflection within the resonant cavity**.

Metal Case

Transmitter

Metal Case

With layer of absorber material

Transmitter
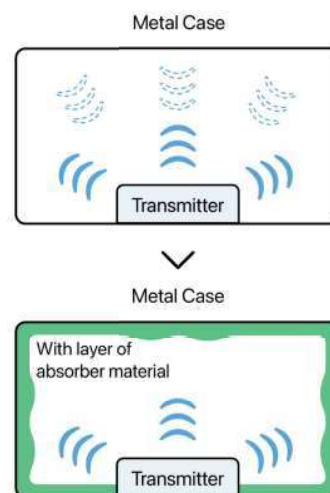
SHIELDING GASKETS

Magnetic-absorber EMC gasket

Elastomer gaskets filled with NANOMAG-Fe are used in the connector area of a metal casing.

This solution supplements the metal shielding provided by the housing, as **it prevents energy leaks that could cause perturbations outside the electronic system**.

FILAMAG,

innovative 3D solution for RF absorption

FILAMAG™
| Features

FILAMAG™ is a range of **magnetic filaments made from polymer filled with magnetic nanoferrite powders** <u>NANOMAG</u>.

HYMAG'IN has the expertise to integrate these powders into different types of rigid or flexible polymer matrices.

FILAMAG™ can be used with standard Fused Deposition Modeling (FDM) 3D printing technology.

Printing properties	
Composition	NANOMAG-Fe Flexible polymer
Loading rate	70% by mass
Extrusion temperature	230 °C
Printer bed temperature	45 °C
Type of printer bed	Textured
Nozzle (recommended)	0.6 - 1 mm
Diameter	1.75 mm

Electromagnetic properties	
Permittivity at 1 GHz	$\varepsilon' = 19.00$; $\varepsilon'' = 3.86$

Frequency (GHz)

Frequency (GHz)
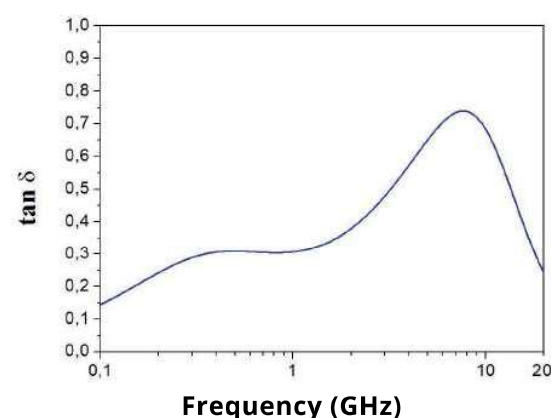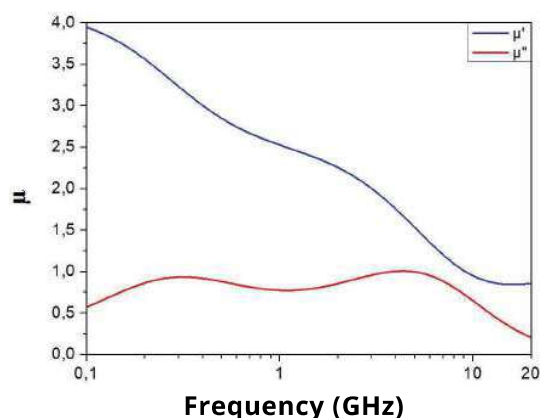
FILAMAG™

| Features

Mechanical properties (measured at 23°C = 73°F)		
Physics	Density	2.8 g/cm
	Hardness **ISO868**	98 Shore A
Traction *Tests performed at 1mm/min* **ISO527-2**	Tensile modulus (Young)	559 MPa
	Maximum tensile stress at break	11 MPa
	Deformation at maximum stress	9.2 %
Bending (3 points) *Tests performed at 2mm/min* **ISO178**	Bending modulus	467 MPa
	Maximum bending elasticity stress	14.9 MPa
	Deformation at maximum stress	8.6 %
Shearing *Tests realised at 2mm/min* **ISO14129**	Modulus of planar shear G_{12}	294 MPa
	Shear stress at break	4.4 MPa

Thermal properties		
ISO75	HDT-B (0,45 MPa)	44°C

Properties of test samples printed with FILAMAG-F, successively at -45 and +45° per layer.

3D-print with FILAMAG™

3D designs are parts printed from a magnetic filament (see FILAMAG-F product sheet), designed to absorb electromagnetic waves. Thanks to this technology, it is possible to create customized structures, adaptable to the specific needs of GHz applications.
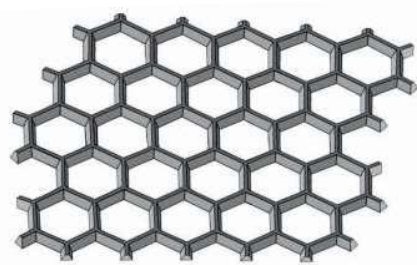
3D-PRINTED SHEET FOR GHZ NARROWBAND

Selecting a ferrite filler with appropriate electromagnetic characteristics and matching the thickness to the required frequency, are essential factors **for optimum absorption**.

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3D-PRINTED HONEYCOMB FOR GHZ NARROWBAND

In the quest for effective absorption of electromagnetic waves, custom-designed shapes play a crucial role. **By customizing the design of your 3D parts, HYMAG'IN targets absorption at the specific frequencies of your EMC requirements.**

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3D-PRINTED MULTISCALE SQUARE FOR GHZ BROADBAND

HYMAG'IN has developed a shape to extend the range of effective frequencies. With FILAMAG-F, **this multiscale square structure absorbs broadband electromagnetic waves in the GHz range.**

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## 3D-PRINTED MAGNETIC CASING FOR CAVITY RESONANCE

HYMAG'IN uses these filaments to produce 3D electronic casings designed to protect electronic boards. These casings complement metal shielding enclosures by preventing wave reflection and cavity resonance.

Upcoming news

DESIGNS 3D – GHz Narrowband: Sheet

The solid sheet is a simple but effective design for applications requiring absorption of electromagnetic waves on a **specific frequency between 1 and 20 GHz.** The flexibility and adjustable dimensions of the solid plate make it an optimal solution for targeting a given frequency according to its thickness, and for easy integration on the surface or inside the system. This product is used in the **telecommunications, electronics and military industries.**
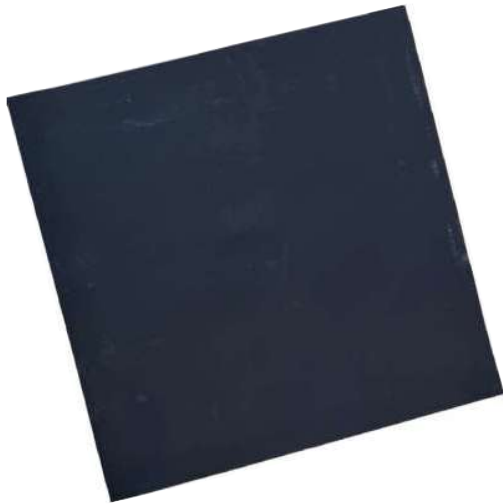
Shape: Rectangular or square

Dimensions:
Thickness adjusted to target frequency.
Length and width adjustable according to specifications.
Ex: 150x150x4mm³ for 3 GHz

Use frequencies:
Adjustable depending on the thickness, **between 1 and 20 GHz**

The graph below illustrates how varying thickness affects the reflection loss of the sheet. Simulations are required to **select the optimum thickness according to the required frequency, performances and system dimensions.**
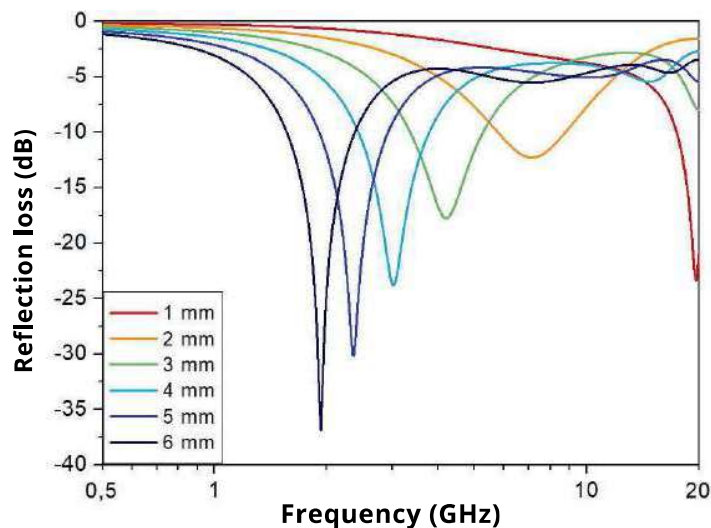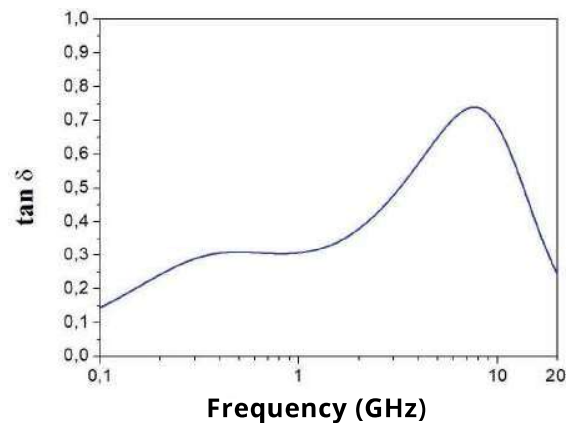
Reflection loss of FILAMAG-F 3D sheet of different thicknesses (simulated)

When thickness is equal to a quarter of the wavelength, a resonance phenomenon occurs, allowing absorption (reflection losses) and **appearance of destructive interferences.**

Electromagnetic properties*	
Permittivity at 1 GHz	$\varepsilon' = 19.00$; $\varepsilon'' = 3.86$
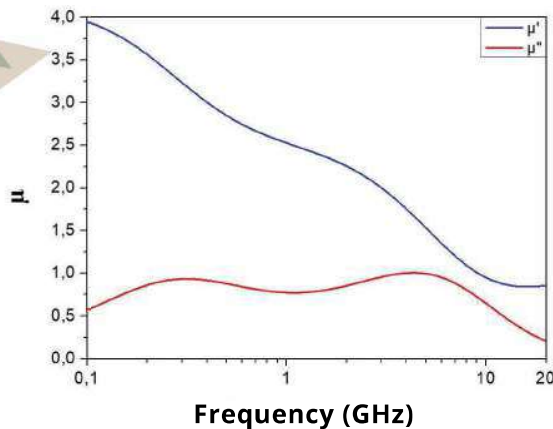
Permeability (measured)

Magnetic loss tangent (calculated)

## Why choose FILAMAG-F [TM] 3D printed sheet?

- Flexible: easy to integrate and place on any surface
- Adaptable dimensions
- No need for machining or cutting

Example of use: in the electronics shielding (by metal casing) of a home energy meter. The conductivity of the metal causes waves to be reflected on the surface of the case, interfering with the electronic components in the cavity and disrupting the operation of the device.
The sheet can be placed in the casing to **prevent reflection of the waves**, and at the joints to **reduce energy leakage.**

*of the filament used: here refer to FILAMAG-F [TM]

DESIGN 3D –
GHz Narrowband: Honeycomb

The honeycomb structure is optimized for the absorption of electromagnetic waves **on a targeted frequency.** This honeycomb design maximizes absorption efficiency while maintaining a **light weight and robust** mechanical structure. By adjusting the dimensions (cell diameter, wall thickness, angle of inclination), absorption can be calibrated to a specific frequency in the GHz range.
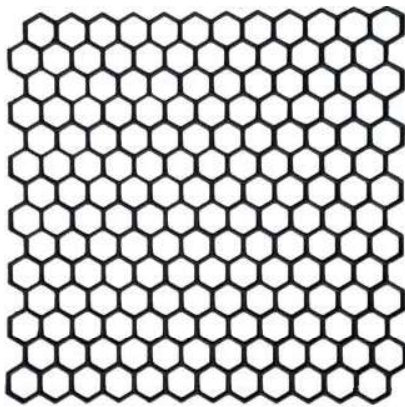
Shape: Alveolar structure

Dimensions:
For 10 GHz : part of 200x200mm² and patterns with dimensions h = 3 mm, p1 = 1 mm, p2 = 3 mm et d = 15 mm

Adjustable dimensions to target other frequencies

Use frequencies:
**Adjustable** on request and according to specifications as system dimensions

Below the results of a 3D honeycomb pattern designed to absorb in the dozen of GHz: significant reflection losses of **-16 dB around 12 GHz** and **a weight three times lighter** than a 3D sheet of the same thickness.
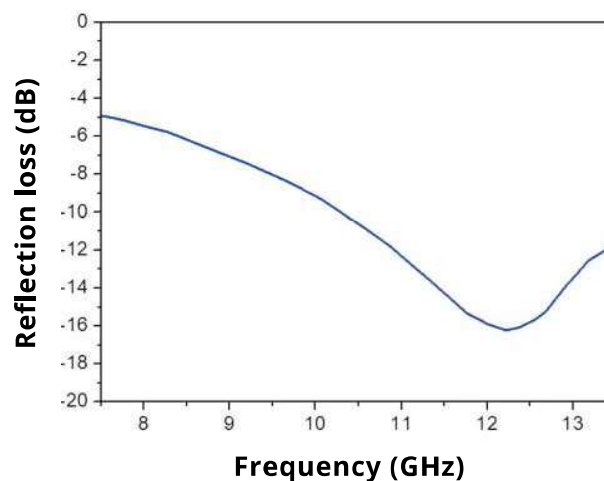

Reflection loss of EU AMAG E 3D honeycomb (measured)

This architecture shows resonance when the cell dimensions correspond to a quarter of the targeted wavelength. This wave will be reflected many times in the cells, generating a **progressive absorption of the wave**, facilitated by the trapezoidal walls (chamfer) which **increase impedance matching** for easier penetration into the material.

Electromagnetic properties*	
Permittivity at 1 GHz	$\varepsilon' = 19.00$; $\varepsilon'' = 3.86$
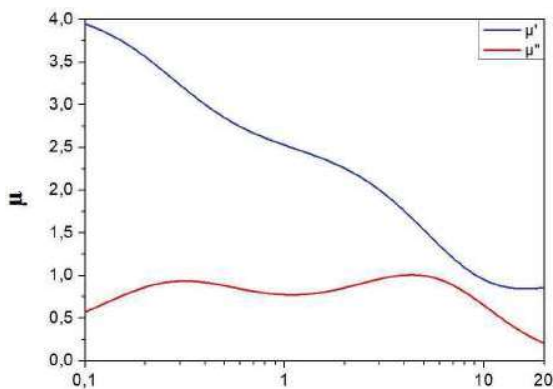
Permeability (measured)
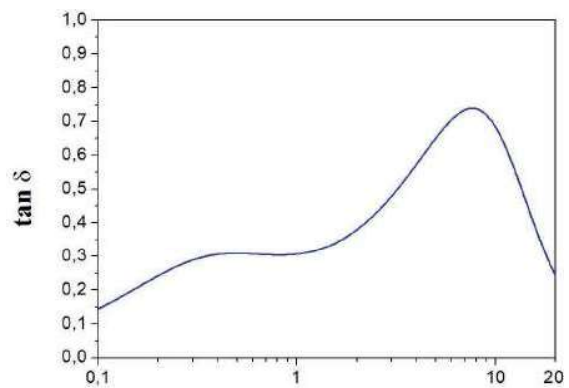
Magnetic loss tangent (calculated)

Developments are underway to extend the absorption bandwidth of the honeycomb structure. This new architecture breaks down into multi-scale cells. With this shaping, **several resonances will appear to allow absorption peaks at different frequencies.**

Why choose FILAMAG-F 3D printed honeycomb?

- Lightweight: performance/weight ratio
- Flexible material
- Customized, adaptable

Example of use: This honeycomb is used by device manufacturers and/or users whose aim is to reduce the reflection of electromagnetic waves on the surface of these systems. This is particularly the case for equipment that needs to **be made undetectable by reducing its radar cross section (RCS).**

*of the filament used: here refer to FILAMAG-F

DESIGNS 3D – GHz Broadband: Multiscale square

The square patterned structure is designed to **extend the frequency range of electromagnetic wave absorption.** Thanks to its modular design, it is particularly suited to environments where GHz broadband performance is required, while allowing **functional integration into devices.**
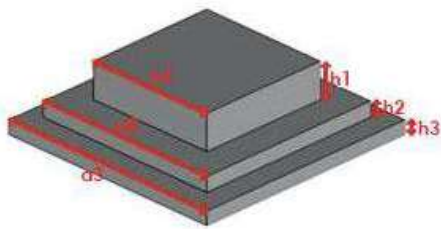

<u>Shape</u>: Square structure with repeating square geometric patterns

<u>Dimensions</u>:
Ex : 200x200x3,7 mm³ and patterns
h1 = 2,4 mm; h2= 0,8 mm; h3= 0,5 mm;
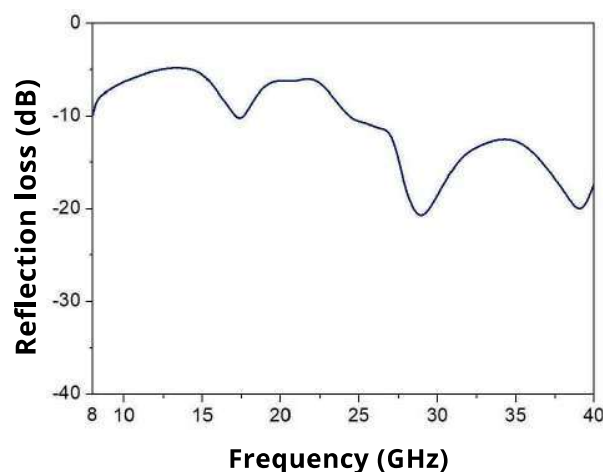a1 = 12 mm; a2 = 18mm; a3 = 20 mm

<u>Use frequencies</u>:
Characterized from 8 to 40 GHz

This GHz broadband absorption is important in a variety of fields, such as **anechoic chambers, radar cross section (RCS) reduction, wireless communications and antennas.**

<u>Reflection loss of FILAMAG-F 3D multiscale square (measured)</u>

Absorption phenomena are induced here by the dimensioning of the patterns. In the lower part of the absorbed frequency range, resonance occurs when the dimensions of the square patterns correspond to a quarter of the wavelength. At higher frequencies, diffraction phenomena allow the wave to penetrate the material.

Electromagnetic properties*	
Permittivity at 1 GHz	$\varepsilon' = 19.00$; $\varepsilon'' = 3.86$
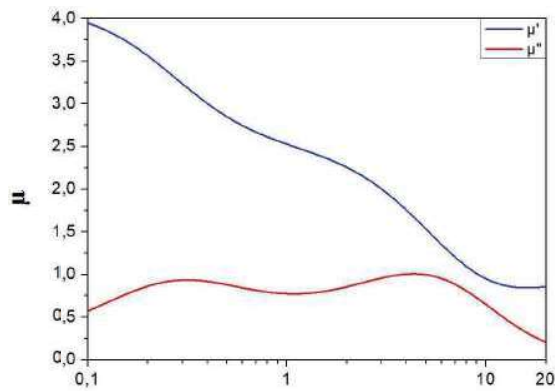
Frequency (GHz)

Permeability (measured)
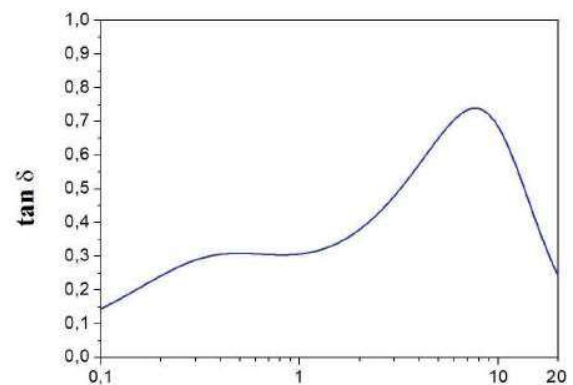
Frequency (GHz)

Magnetic loss tangent (calculated)

R&D trials on this design are currently underway, with the aim of **extending the frequency range** by developing a new printing filament. **Increasing peak reflection losses** is also a major challenge, and one that will require research into new, even more efficient, broadband designs.

**Why choose FILAMAG-F 3D printed square structure?**

- Mechanically robust
- Volume gain

Example of use: These repeated square-pattern structures can be used in **anechoic chambers** to replace GHz pyramidal absorbers. These designs are more compact than pyramids, saving space.

*of the filament used: here refer to FILAMAG-F

Why choose FILAMAG™?

Geometry selection to match the space complexity of your use case:

FILAMAG™ filaments enable to print absorbing parts as precisely as required to match the geometry of your electronic systems. The structure of the printed materials, micro-pyramids or honeycombs for example, and their dimensions are accurately calibrated during the set up of the 3D printing.
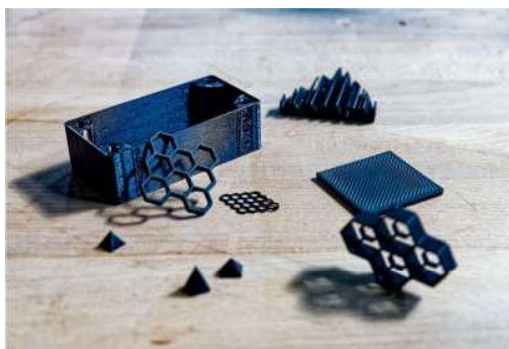
*Performance optimization and weight reduction of your absorbers:*

Through a relationship linking the geometry of the absorber and its interaction with electromagnetic waves, designing 3D-printed absorbers with FILAMAG™ considerably **improves their performance while lightening their structure**.

Parameters adaptation related to your required mechanical properties:

The chosen matrix for the filament and the loading rate of NANOMAG powder have a direct impact on the final mechanical properties of the printed part. **HYMAG'IN is able to adapt these parameters to suit user requirements**.

FILAMAG-F stands out other filaments by its flexibility. They are used to print absorber products that require flexibility for integration into the system and for use under mechanical stress, for example.
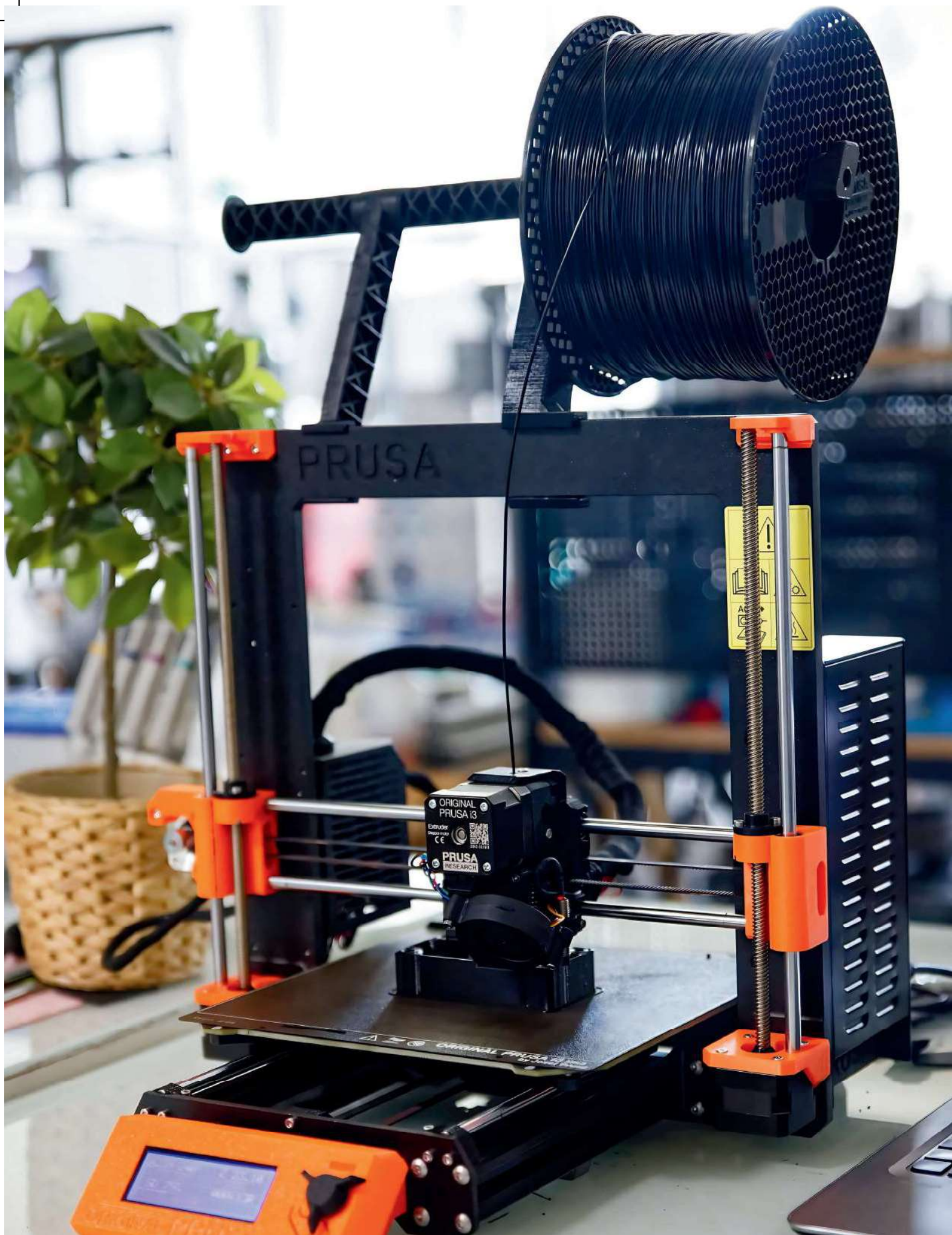
CONTACT US

FERRITES AND OTHER TAILOR-MADE PRODUCTS

Do you want to explore new applications and uses of ferrites?
Are you looking for new formulations of ferrite materials?
Do you have specifications on filament properties?

Our experts look forward to hearing from you about:

- **Exploring new formulations of ferrites;**

- **Developing composite materials with higher flexibility, higher performances or 3D specific design;**

- **Characterization of your products in terms of chemistry, magnetism and electromagnetism properties;**

- **Investigating new and trendy applications for magnetic materials.**

NEED MORE INFORMATION?
CLICK HERE TO CONTACT US

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