Printed Electronics for space applications: An approach towards the integration of passive electronics

Miren Hayet Otero[1] [2], Julen Caballero Anton[1] [2], Leire Bilbao Alba[1], Ana Perez Marquez[1], Olatz Adarraga[1], Ibai Santamaría[1], Izaskun Bustero[1], Jose Manuel Gonzalez[2]

[1]Tecnalia, Spain

[2]University of the Basque Country (EHU)

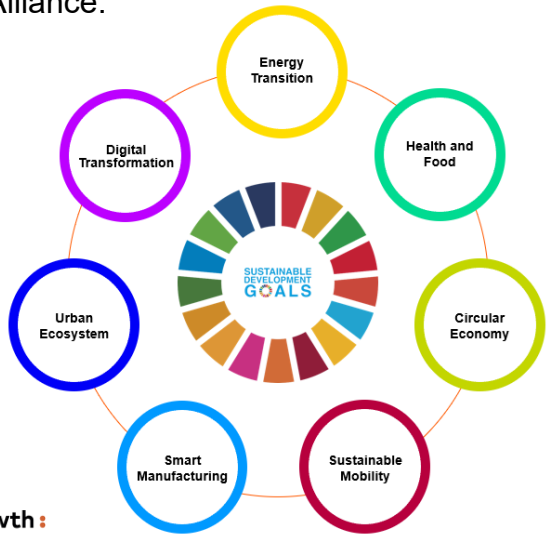
6th Space Passive Component Days (SPCD), International Symposium

- ESA/ESTEC, Noordwijk
- 16/10/2026

Who are we?

Tecnalia is the largest applied research and technological development centre in Spain, and member of the Basque Research and Technology Alliance.

1520



Creating Growth : Improving Society

PRINTEX
Printed Electronics team

9

Localized deposition of functional inks on any surface by means of additive technologies.

Integrate functionalities where it was not feasible before.



Outline

4 Printed Electronics
9 AME antenna for ISM band
11 AME filter
13 Sensors embedded into composite
15 Thermally self-regulated composite component

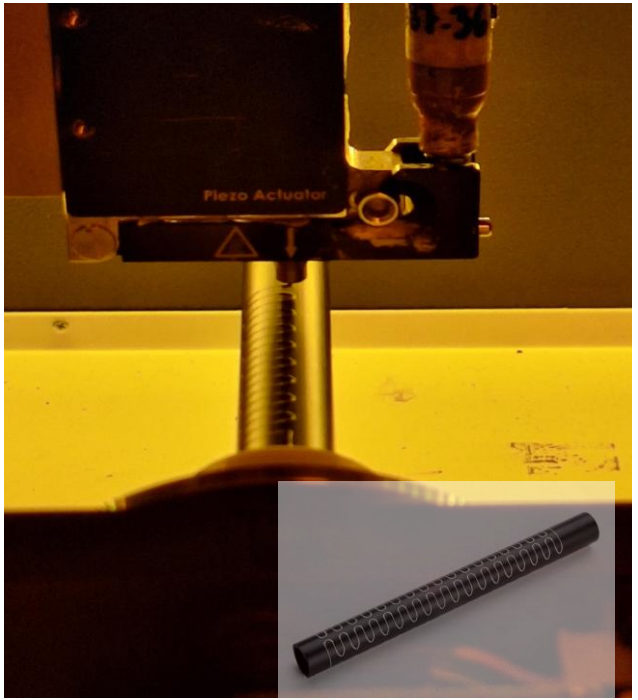
Printed Electronics

Controlled deposition of functional materials onto a surface with the objective of endowing the resulting object with active additional (electronic) properties.

Inks with electrical properties (conductive, resistive, dielectric) or stimuli-responsive materials.

- Additive technology ↔ material/waste reduction
- Unified workflow: structural fabrication + functionalization
- Weight and volume reduction
- Costs reduction
- Geometric freedom
- Solder-free assembly

Space applications:
- Material validation
- Low TRL

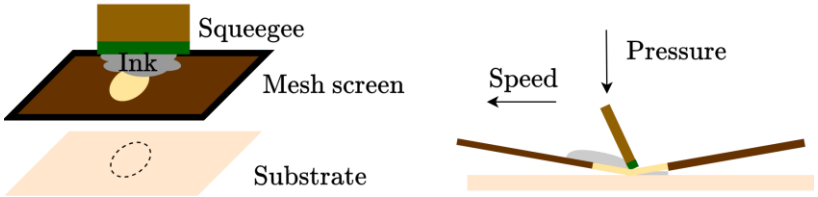


Printed Electronics

DEPOSITION TECHNIQUES – 2D

Screen-Printing

- Transfer of ink through a mesh.
- Fast (~ s/screen)
- **Most mature**, scalable: widely adopted by the industry.
- Resolution > 90 µm
- Limited to **planar substrates**.



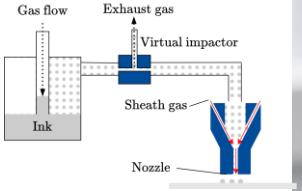


Printed Electronics

DEPOSITION TECHNIQUES – 3D

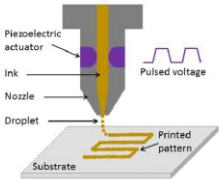
Aerosol Jet

Aerosolized-ink mist directed to the substrate in the form of a high-speed jet.



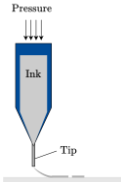
Piezojet

Piezoelectric-based, non-contact deposition of ink micro-droplets.



Micro-dispensing

Pressure-aided ink deposition.

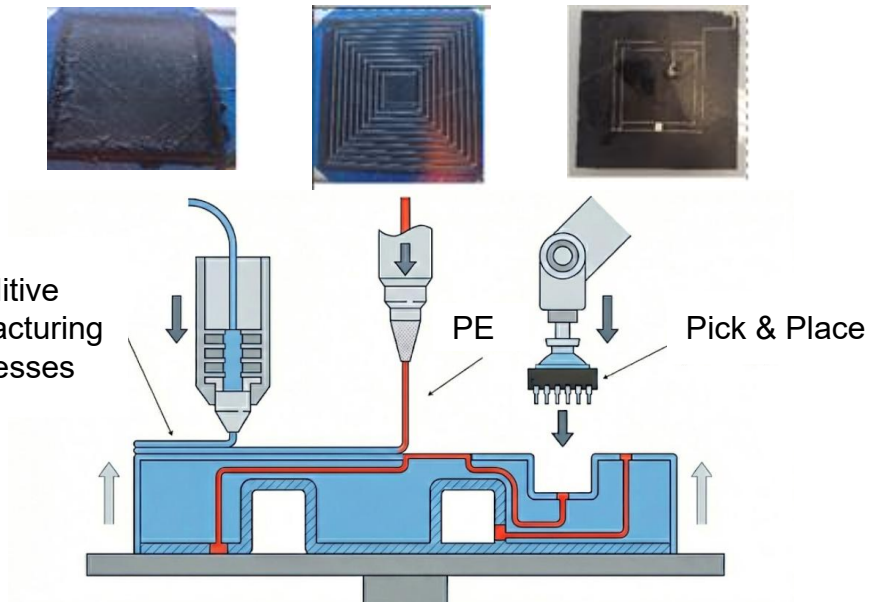


Materials		Characteristics	
η (CP)	1 - 1000	**v (mm/s)**	1 - 10
		$d_{substrate}$	1 – 5 mm
Particle size	1 - 5 µm	**Resolution**	20 – 250 µm
η (CP)	2 - 2000	**v (mm/s)**	15 - 100
		$d_{substrate}$	1 – 3 mm
Particle size	Nano-micro scale	**Resolution**	200 – 1000 µm
η (CP)	50 - 100000	**v (mm/s)**	1 - 500
		$d_{substrate}$	~ 300 µm
Particle size	Nano-micro scale	**Resolution**	100 – 1000 µm

Printed Electronics

ADDITIVELY MANUFACTURED ELECTRONICS (AME)

Sequential **combination** of conventional **additive manufacturing processes** (FFF, SLA…) with **PE** techniques.





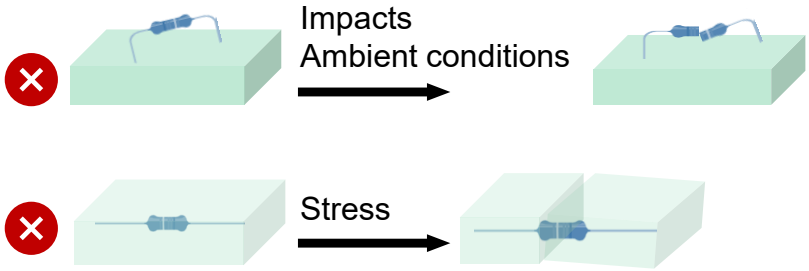
Printed Electronics

MULTIFUNCTIONAL COMPOSITES

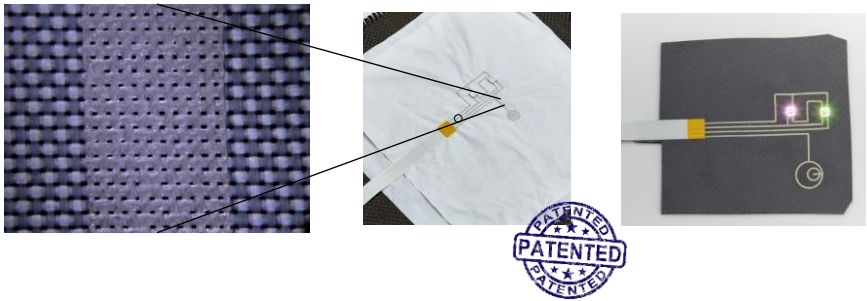
Structural properties of Fibre-Reinforced Polymer Composites (FRPC):
- Stiffness
- Strength to weight ratio.

+

Non structural functionalities:
- Sensors/Structural Health Monitoring (SHM)
- Heaters
- Lightning



Printed Electronics
Printed patterns allow resin flow → do not generate discontinuities → structural properties are preserved.



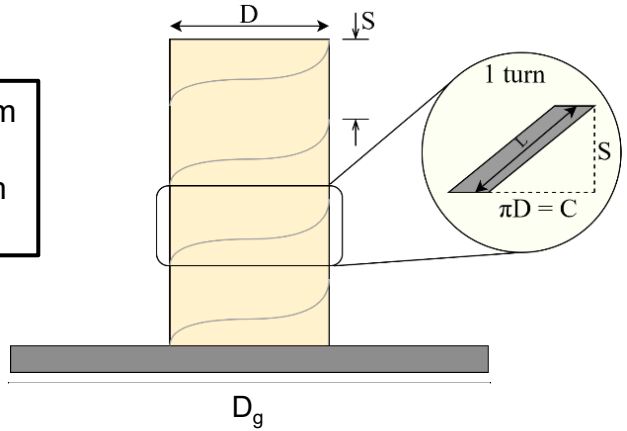
AME antenna for ISM band

DESIGN

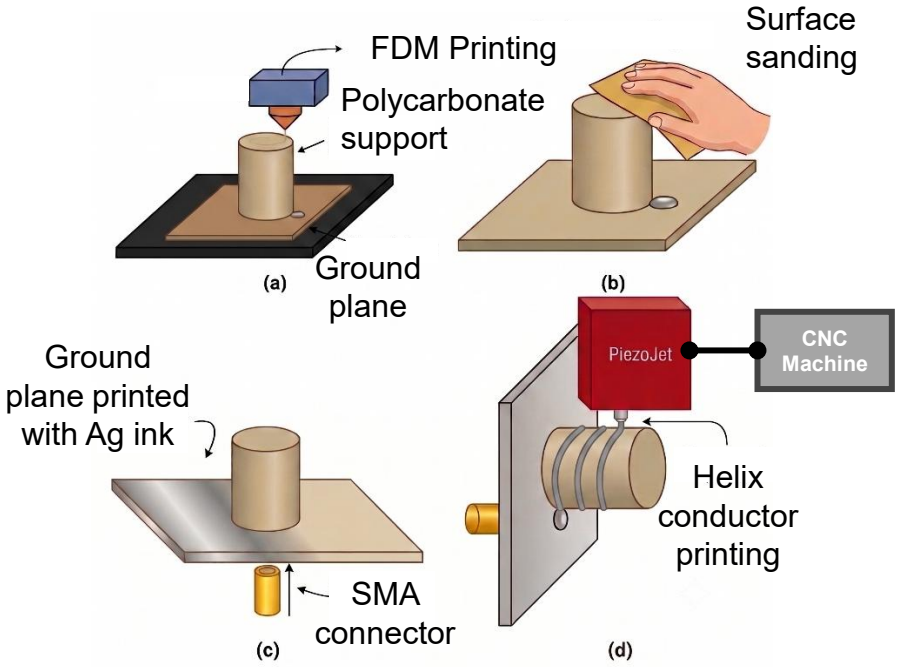
Application: Satellite-to-ground communication (0-10 dBi)

Target gain: 3 dBi → Helical antenna

D = 27.5 mm
S = 8 mm
W = 600 µm
D_g= 74 mm



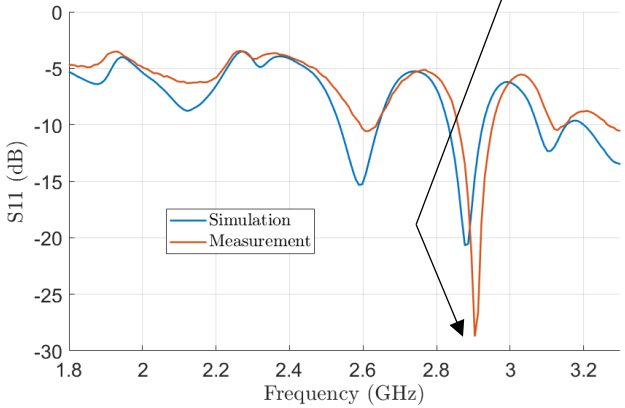
MANUFACTURING

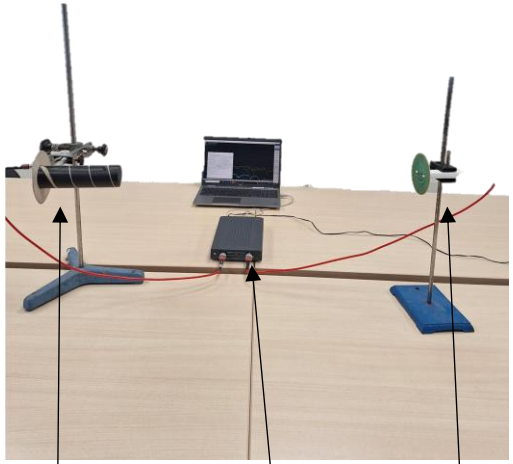


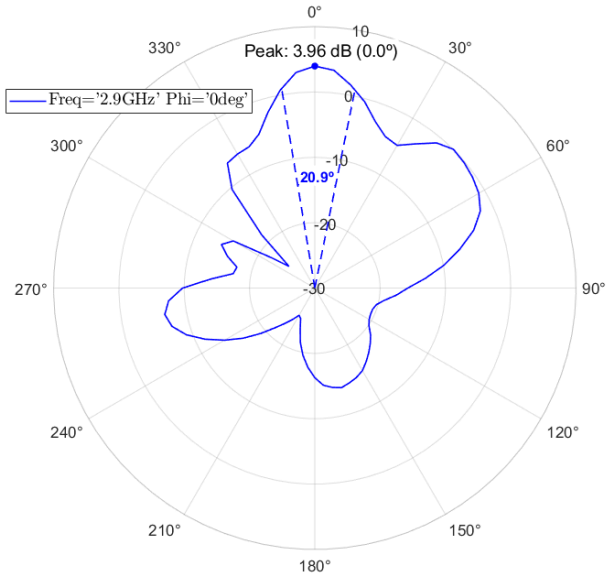
AME antenna for ISM band

RESULTS









$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi d}\right)$$

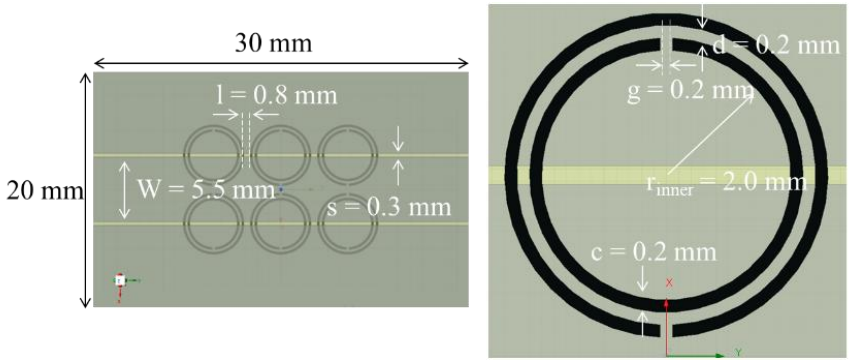
AME filter

DESIGN

Planar miniaturization of microwave filters: CPW technology + metamaterial-inspired resonators**.**

AME enables new filter topologies: stacked/embedded resonator networks in printed dielectric volumes.

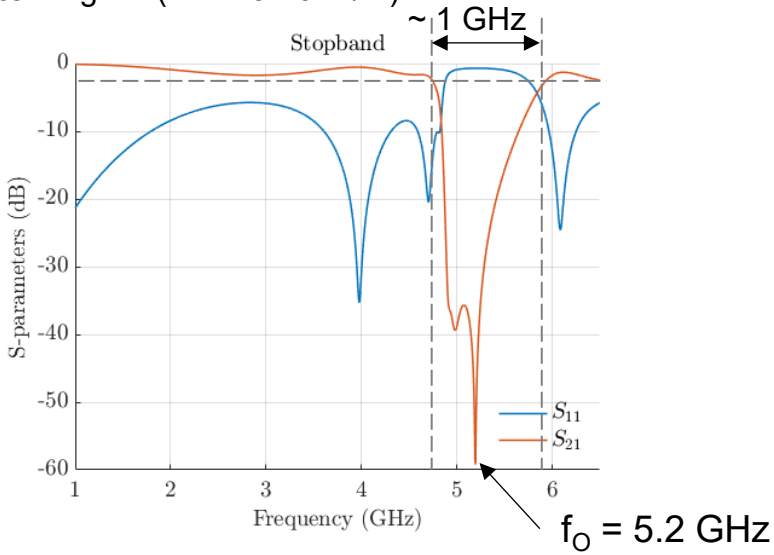
Preliminary analysis: Single-layer CPW stopband filter.



SIMULATIONS

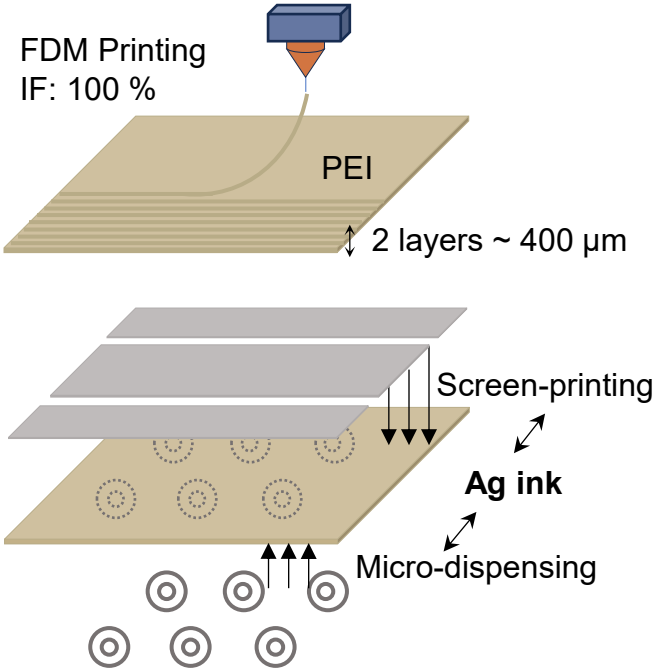
Substrate: h = 400 μm PEI (ε_r = 3.0 – 3.2, tanδ = 0.0027)

Conductor: Ag ink (σ = $1.3 \cdot 10^7$ S/m)

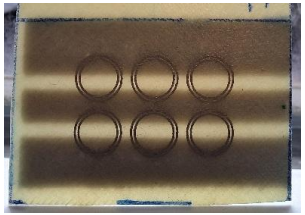


AME filter

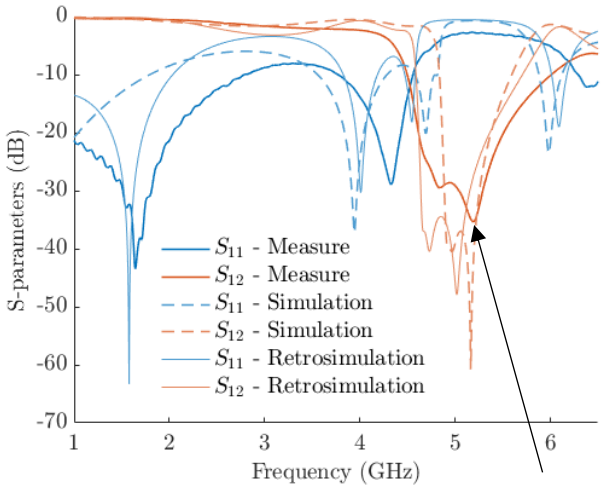
MANUFACTURING



RESULTS



Parameter	Measured	Design
d (µm)	197 ± 9	200
c_{in} (µm)	220 ± 10	200
c_{out} (µm)	200 ± 10	200
g_{in} (µm)	270 ± 70	200
g_{out} (µm)	270 ± 50	200
R_{in} (mm)	2,02 ± 0,02	2
W (mm)	4,95	5.5
s_1 (mm)	1	0.3
s_2 (mm)	1	0.3

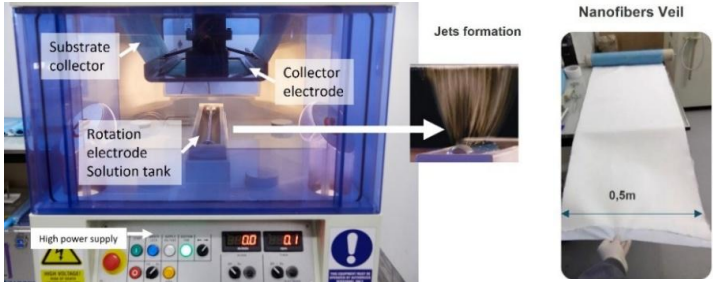


f_O = 5.2 GHz

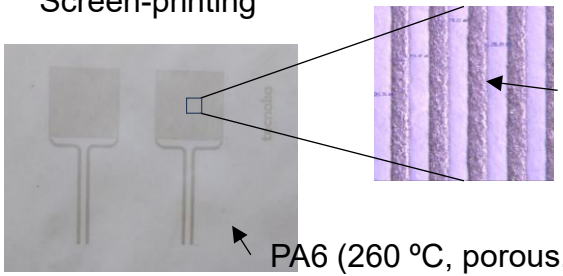
Sensors embedded into composite

MANUFACTURING

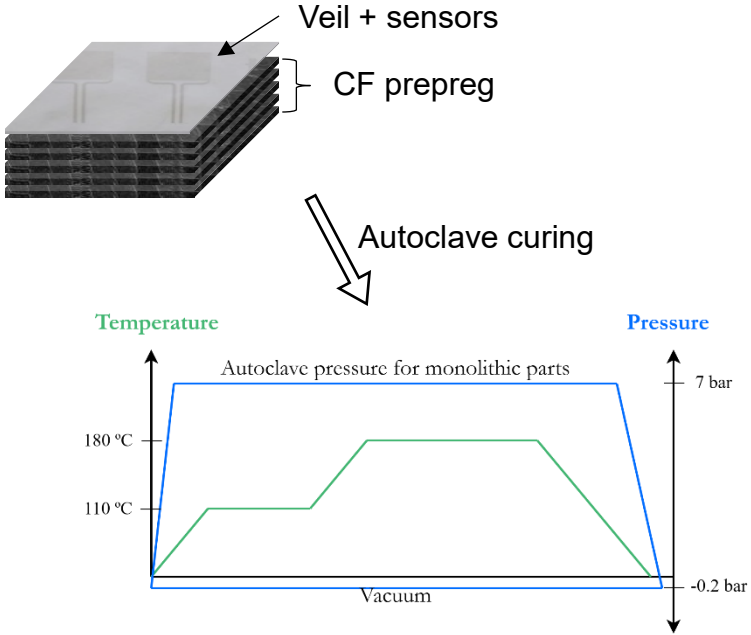
Electrospinning technology → PA66 Nanofibrous veils



Screen-printing



Composite integration

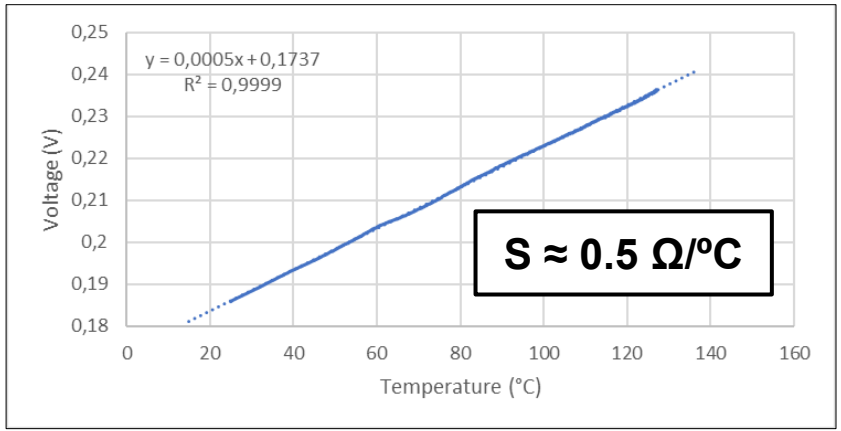


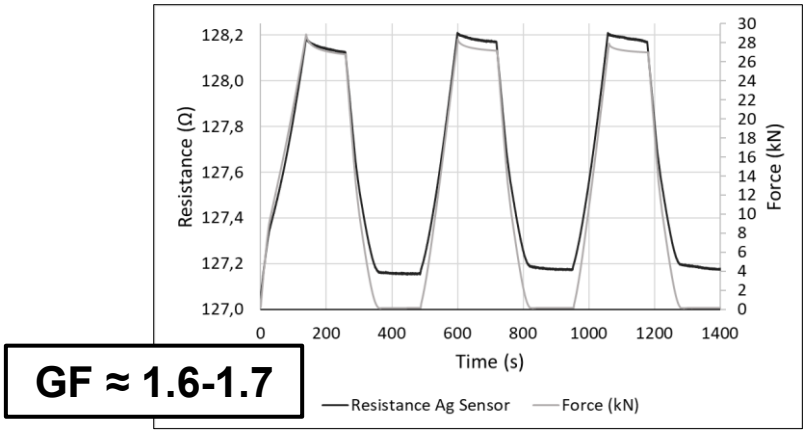
Sensors embedded into composite

RESULTS

Thermal characterization
- Oven
- Cycles up to 130 ºC.

Mechanical tests:
- Tensile tests UNE-EN ISO527-4 standard + contact extensometer
- Cycles up to 0.5% strain.





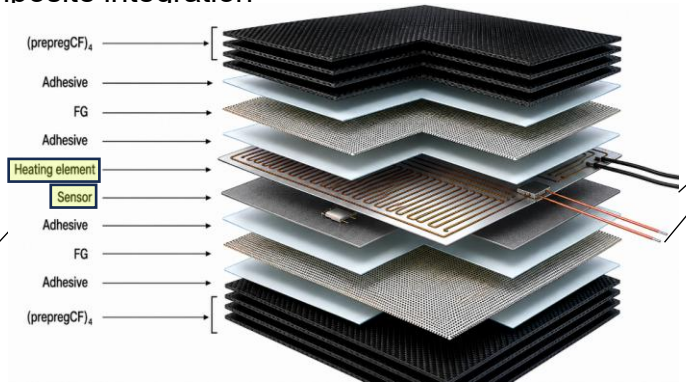
Thermally self-regulated composite component

MANUFACTURING

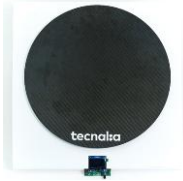
Heating element:
- Screen-printing
- Ag ink
- Substrate: fibreglass fabric

Temperature sensor:
- Screen-printing
- Ag ink
- Substrate: PA66 veil

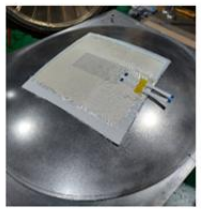
Composite integration

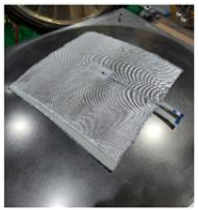


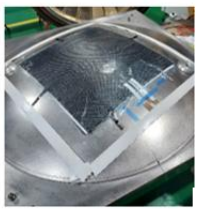
Connections:
- Flat flexible cables
- Conductive adhesive



R (Ω)	Heating element	Sensor
Pre	6,6	222
Post	6,7	221







Autoclave:
- 120 ºC
- 1 bar

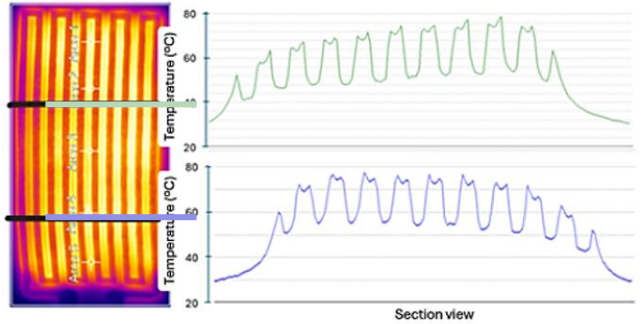
HEATER SENSOR CF Laminate

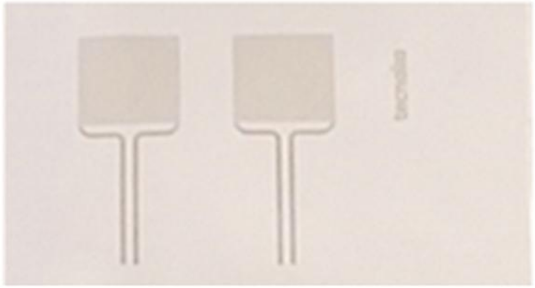
Thermally self-regulated composite component

RESULTS

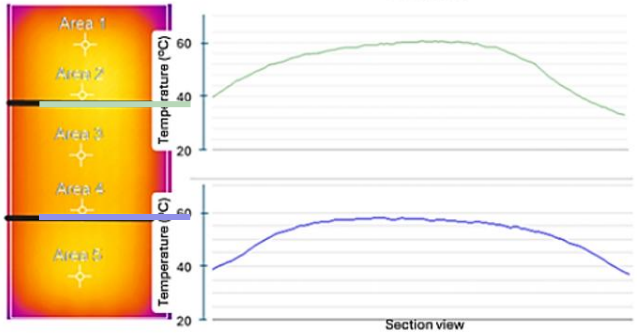
Thermal distribution (12 V – 70 ºC)

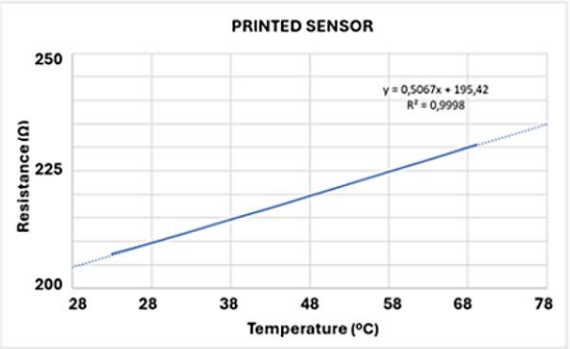
Dry



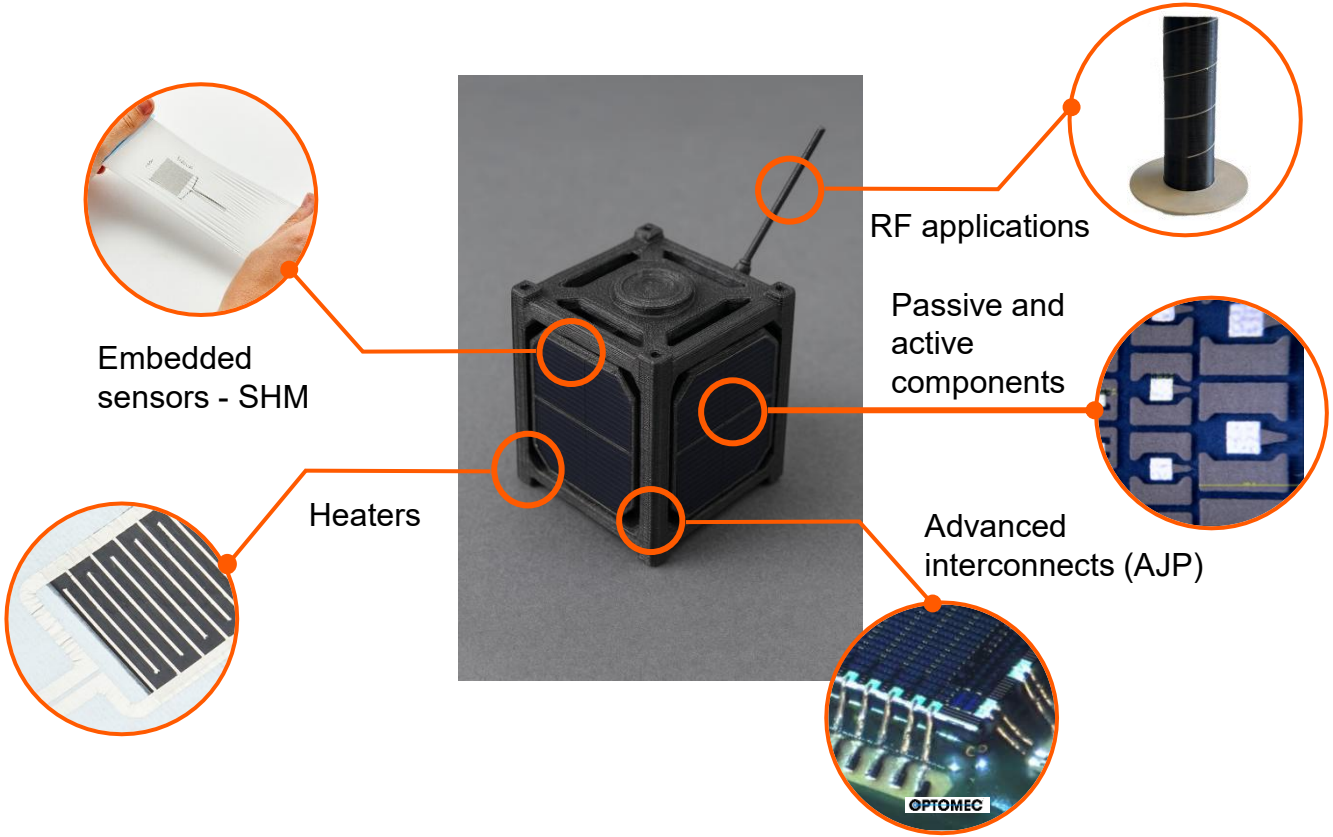


Post-embedding





What's next?


Embedded sensors - SHM
Heaters
RF applications
Passive and active components
Advanced interconnects (AJP)
OPTOMEC

Thank you!

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miren.hayet@tecnalia.com
ibai.santamaria@tecnalia.com