



Nanostine

The scalable way to do nanocoatings

M.A.R.S. 3

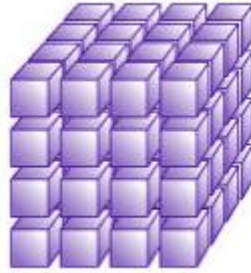
Nanopartículas: la base de recubrimientos avanzados



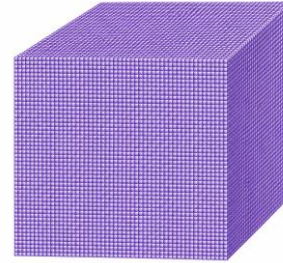
4 cm side
 $A=96 \text{ cm}^2$
 $V=64 \text{ cm}^3$
 $S/V = 1.5$



2 cm side
 $A=192 \text{ cm}^2$
 $V=64 \text{ cm}^3$
 $S/V = 3$



1 cm side
 $A=384 \text{ cm}^2$
 $V=64 \text{ cm}^3$
 $S/V = 6$



10 nm side
 $384 \text{ millions cm}^2 = 38,400 \text{ m}^2$
 64 cm^3
 $S/V = 6 \text{ millions}$



Nanopartículas: la base de recubrimientos avanzados

Los **bloques de construcción del recubrimiento** con partículas a **escala nanométrica** cambian tres cosas:



Mayor reactividad
gracias a una superficie mucho mayor



Nuevas propiedades (ópticas, eléctricas, catalíticas)
derivadas del tamaño y de los efectos cuánticos



Rendimiento adaptado a la aplicación
haciendo los materiales más ligeros, duros, duraderos y antiadherentes

Ejemplo: El oro cambia a escala nanométrica

A granel



Amarillo, reflectante



Baja reactividad



Usado en joyería y contactos eléctricos



Lingote de oro

Nanopartículas



De rubí a púrpura



Alta reactividad superficial

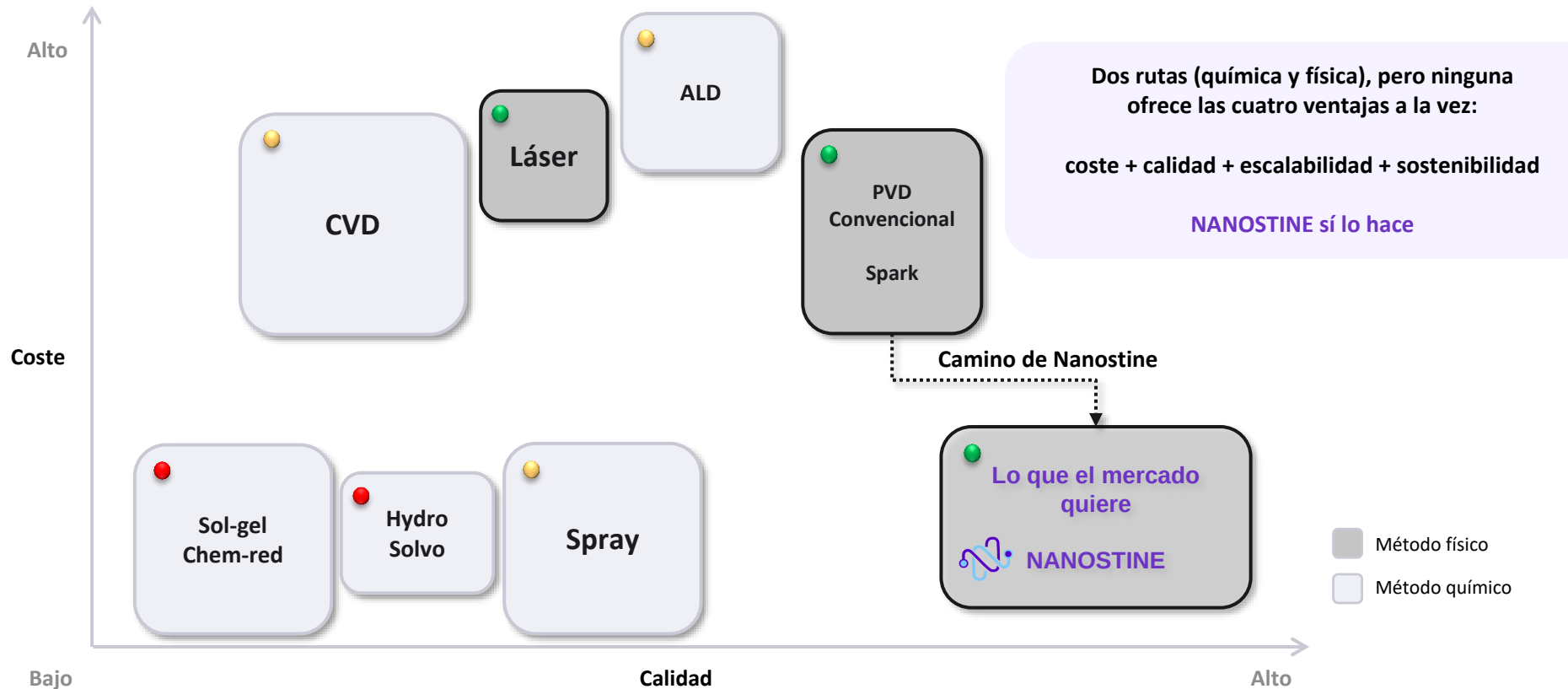


Usado en catálisis, biosensado y aplicaciones médicas



Nanopartículas de oro: el color varía con el tamaño

Aplicar las nanopartículas hoy obliga a elegir

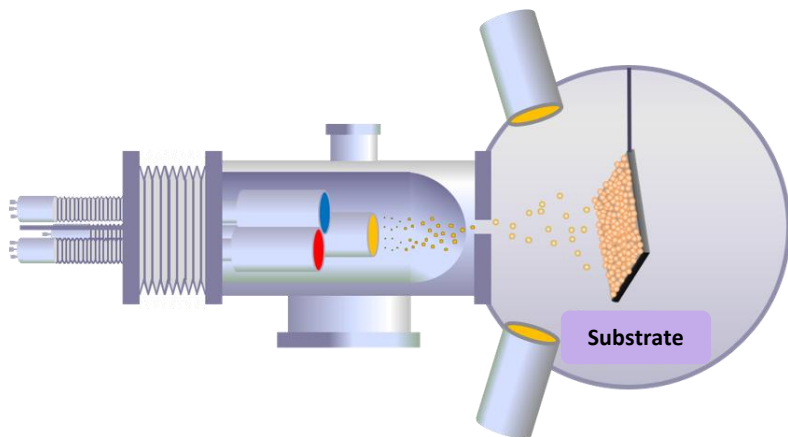


Tamaño = Escalabilidad (pequeña → grande). Sostenibilidad = ● buena, ● media, ● mala



Technology: Industrial precision and scalability

Our **proprietary** MICS (Multiple Ion Cluster Source) technology enables the manufacturing of **complex nanoparticles** with **atomic-level precision** and **industrial stability**.



Full control

Generation of alloys and complex nanostructures in a single step using **three independent magnetrons**.

Industrial scalability (the “race track” issue solved)

We have solved the typical instability of conventional sputtering by using our proprietary **Full-Face Erosion (FFE) magnetrons**.

Stability data

Validated continuous operation for more than 12 hours without replacing the feedstock, achieving 20 % target utilization (vs. 5-10 % standard), significantly reducing OPEX and maintenance downtime.

Nanostine: High-performance coatings at scalable cost



Precision and purity

Ultra-thin conformal layers (from single-particle-thick coatings to films of several μm) with thickness control of $\pm 2\text{--}10\text{ nm}$.

Very low impurities, resulting in higher performance and reliability.



Cost and scalability

Lower cost per m^2 than traditional methods: **up to 33% lower than CVD and 50% lower than laser**, with better quality.

High productivity compatible with volume manufacturing. Cycle times per part can be **just a few seconds**.

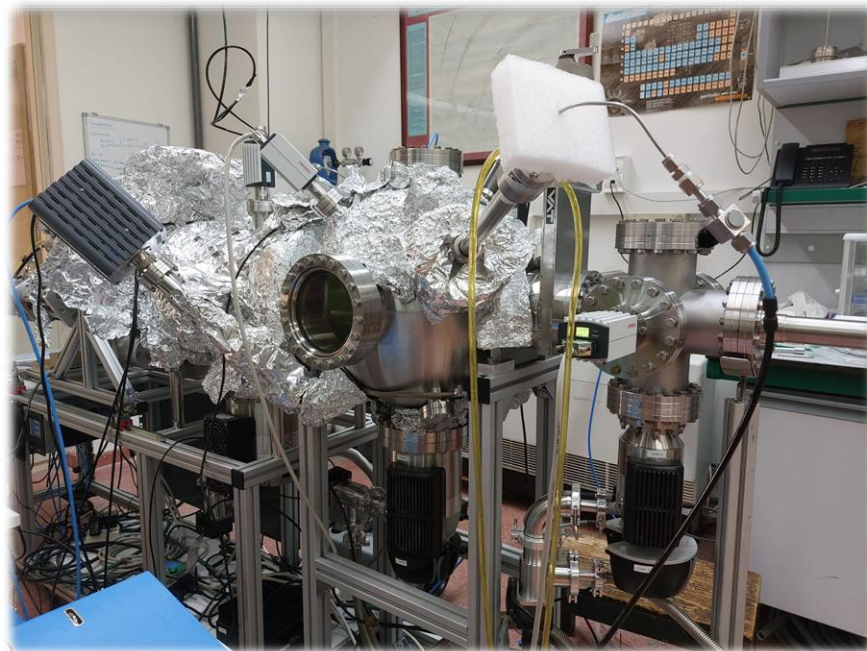


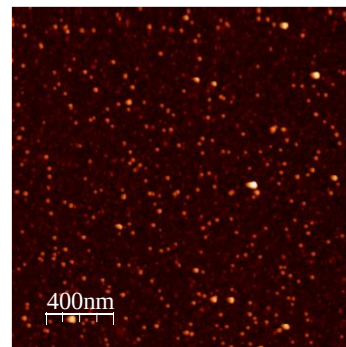
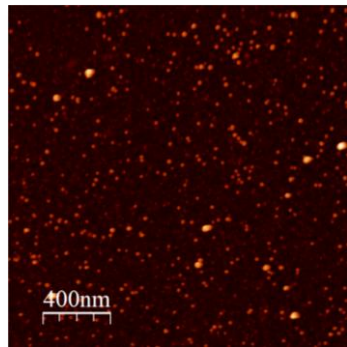
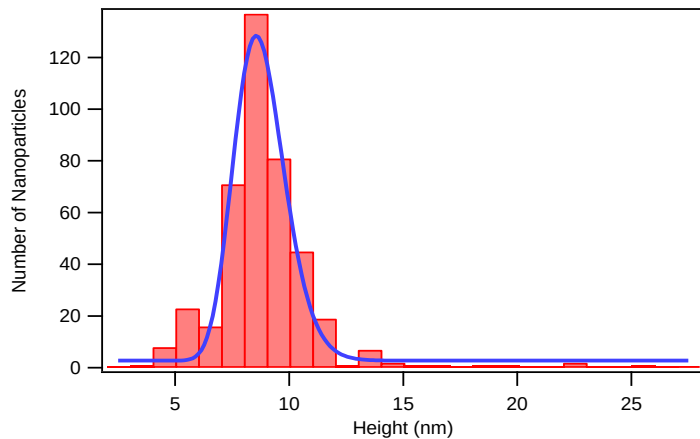
Sustainability

Dry process, with no solvents or hazardous reagents (vs. chemical alternatives).

Reusable raw material, reducing cost.

Nanostine is a CSIC spin-off with patented technology*

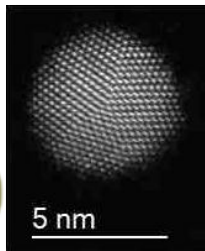




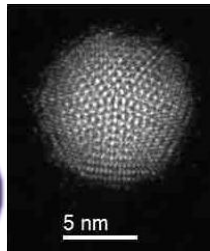
Homogeneous nanoparticle distribution.
No agglomerate formation.
Deposits <1 monolayer.
Controlling the number of nanoparticles per μm^2 .



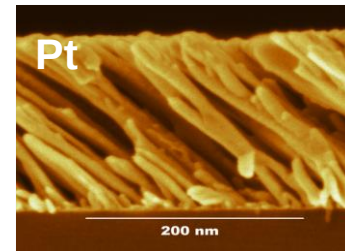
Examples of broad product portfolio



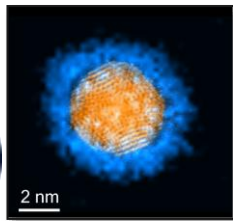
Single element



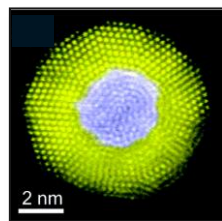
Alloys



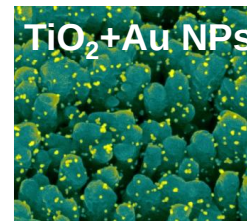
Nanocolumns



*Oxidized
nanoparticles*



Core-shell



Nanocolumns + nanoparticles



Elements **used by Nanostine** in nanoparticle synthesis



SpaceTech success story #1: Radiofrequency

Problem

Multipactor effect, a phenomenon in which electrons bounce between metallic surfaces inside RF devices, creating a cascade that overheats or destroys components. Existing coatings (Alodine, SurTec) mitigate it only partially:

1. **Alodine** uses hexavalent chromium (Cr VI), a carcinogen restricted under the European REACH regulation (Registration, Evaluation, Authorization and Restriction of Chemicals).
2. **SurTec** is REACH-compliant but provides weak multipactor suppression, forcing operation at lower RF power levels or requiring device redesign.

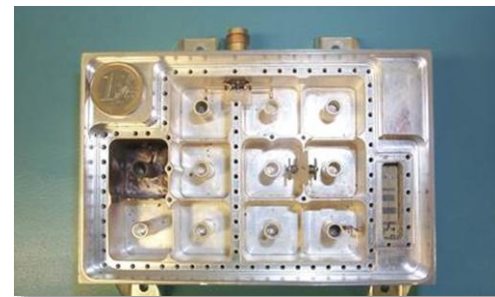
Solución de Nanostine

REACH-compliant nanostructured coatings that drastically reduce secondary electron emission while maintaining electrical conductivity and mechanical stability (-150 °C to +150 °C).

Validation to date

ESA BIC Madrid and ESA IDEAS-OSIP projects with ESA and SENER.

Performance improvement of x 3–7 (first crossover energy (E_1) = 130 eV vs. 41 eV (Alodine) and 18 eV (SurTec); discharge threshold (ΔP): 7–9 dB vs. 3.3–7.7 dB for Alodine 1200).

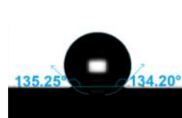
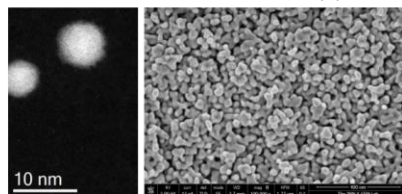
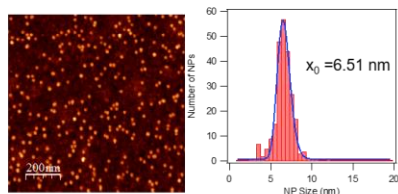


Comparison between a flat surface (left) and a nanoparticle-textured surface (right) to mitigate the multipactor effect. Electrons escape more easily from less rough surfaces (without nanoparticles).

Nanostine technology enables nanometric control of coating properties, complying with REACH conditions and ESA requirements.

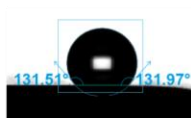
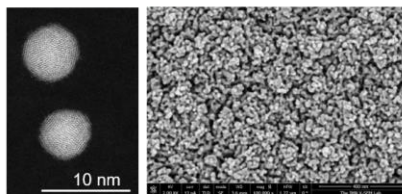
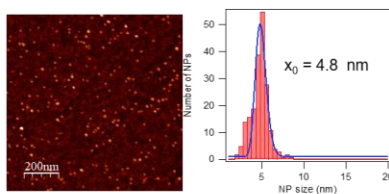
ECSS-Q-ST-70-02C. Thermal vacuum outgassing.
ECSS-Q-ST-70-05C. Detection of organic contamination.
ECSS-E-ST-20-01C. Multipactor design and test.
ECSS-E-HB-20-01A. Multipactor handbook.

Ag₇₀Au₃₀ NPs coating (C)



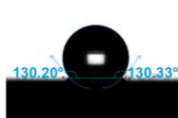
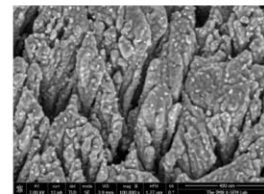
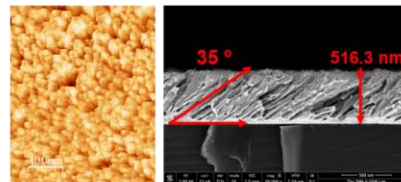
Hydrophobic ✓
Homogeneity ✓
Roughness: 25 nm

Ag₃₀Au₇₀ NPs coating (D)



Hydrophobic ✓
Homogeneity ✓
Roughness: 25 nm

Au NCs + Ag₇₀Au₃₀ NPs coating (E)

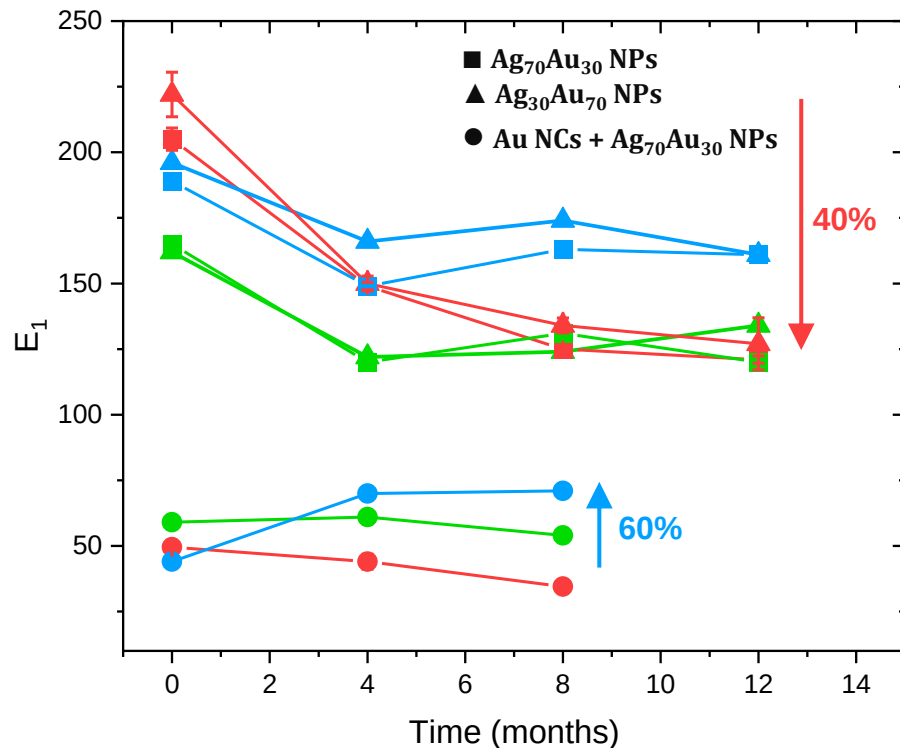


Hydrophobic ✓
Homogeneity ✓
Roughness: 35 nm

NP: nanoparticle; NC: nanocolumn

Nanostructured Coatings for Multipactor Mitigation

Ageing of the AgAu nanostructured coatings: SEY parameters at 20°C



E_1 (Alodine) $\approx 39,8$ eV; NP: nanoparticle; NC: nanocolumn

Vacuum

- NPs: slight degradation ($\downarrow 15\%$)
- NCs+NPs: slight degradation ($\downarrow 15\%$)

Controlled Humidity (55%)

- NPs: degradation ($\downarrow 40\%$) $\rightarrow \sim 130$ eV
- NCs+NPs: degradation ($\downarrow 30\%$)

Nitrogen

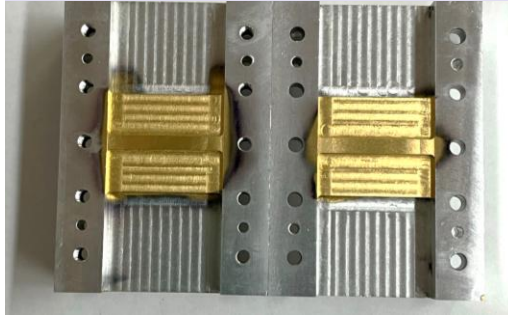
- NPs: slight degradation ($\downarrow 15\%$)
- NCs+NPs: improvement ($\uparrow 60\%$) $\rightarrow \sim 70$ eV

- NPs-based coatings show a much higher E_1 than Cs coatings.
- The behaviour of the NPs coatings is similar for both alloys, showing a slight degradation in vacuum and nitrogen in the first 4 months, but remaining stable thereafter, and showing a higher degradation in the controlled humidity environment.

Nanostructured Coatings for Multipactor Mitigation

WR-90 waveguides Ku band transformers

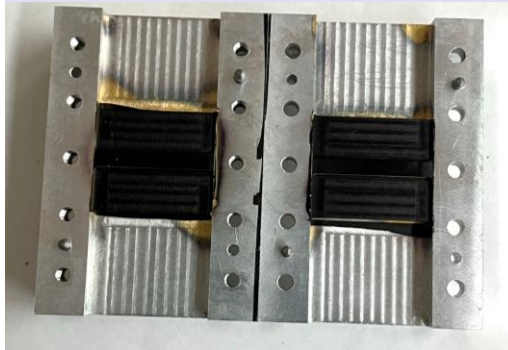
TB: 4 μm Au Thin Film



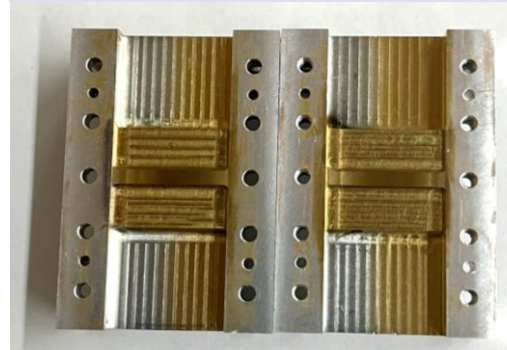
TC: 4 μm Au TF+ 2 μm Ag₇₀Au₃₀ NPs



TD: 4 μm Au TF + 2 μm Ag₃₀Au₇₀ NPs

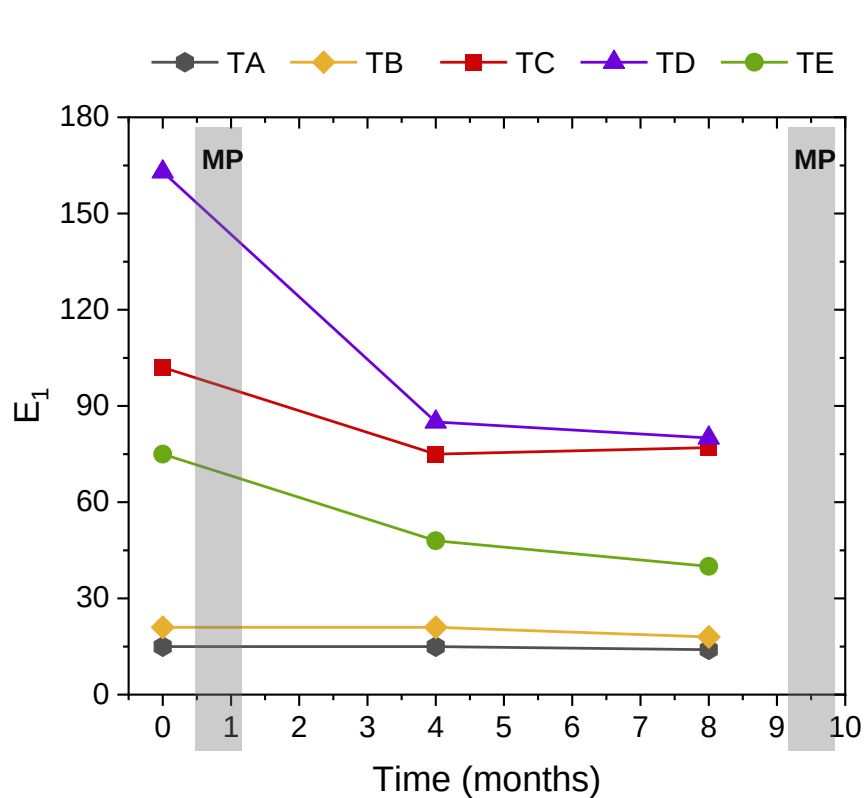


TE: 4 μm Au TF + Au NCs + Ag₇₀Au₃₀ NPs

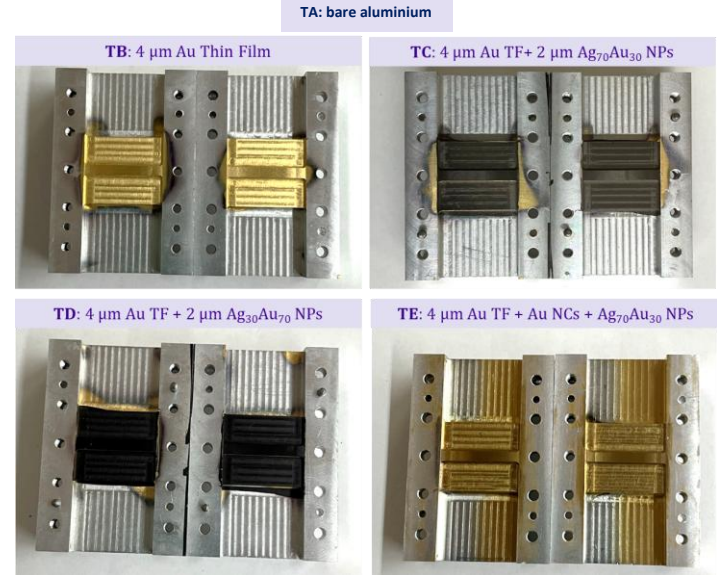


Nanostructured Coatings for Multipactor Mitigation

Ku-band Transformers: SEY measurements at 20°C. Stored in controlled humidity environment.



E_1 (Alodine) $\approx$ 39,8 eV; NP: nanoparticle; NC: nanocolumn



- Nanostructured coatings (TC, TD and TE) are notably better than the references (TA, TB and alodine).
- Decrease in E_1 following the multipactor test.
- E_1 stable between months 4 and 8.

Ku-band Transformers: S-parameter measurements and multipactor test

Device	Description	Time (month)	VNA		Lowest multipactor threshold (W)		ΔP (dB)
			S21 [dB]	S11 [dB]			
TA	Bare Al	0	-0.09	-31.94	600	$\downarrow 16\%$	0
		8	-0.10	-34.25	502		0
TB	Au Thin film	0	-0.10	-24.14	950	$\downarrow 33\%$	2.0
		8	-0.10	-25.52	632		1.0
TC	Ag ₇₀ Au ₃₀ NPs	0	-0.10	-29.96	3875	$\downarrow 31\%$	8.1
		8	-0.11	-33.38	2680		7.3
TD	Ag ₃₀ Au ₇₀ NPs	0	-0.08	-36.05	4764	$\downarrow 50\%$	9.0
		8	-0.09	-44.35	2388		6.8
TE	Au NCs + Ag ₇₀ Au ₃₀ NPs	0	-0.09	-27.78	3373	$\downarrow 11\%$	7.5
		8	-0.09	-31.39	3006		7.8

Frequency	=	10950 MHz
Pressure	<	$1.5 \cdot 10^{-5}$ mbar
Temperature	=	+22°C
Duty cycle	=	2 %
PRF	=	1 kHz
Maximum RF power	=	5.5 kW Pulsed

- No significant deviations observed in transmission (S21) over time.
- Slight improvement of reflectivity (S11) over time.
- Decrease in the lowest MP threshold over time.
- **Nanostructured coatings (TC, TD and TE) are notably better than the references (TA and TB) even after 8 months.**

ΔP for Alodine 1200 over AA2024 Aluminium : 3.3 - 7.7 dB. C-band waveguide. Gap: 0.28 - 2.0 mm. Test frequency 5.3GHz. Ref. ESTEC WP No. 1556

SpaceTech success story #2: Self-cleaning lenses

Problem

Fingerprints, organic stains and fogging on external glass surfaces **degrade image quality**.

Nanostine solution

Self-cleaning photocatalytic coatings based on titanium dioxide nanocolumns (TiO_2 NC).

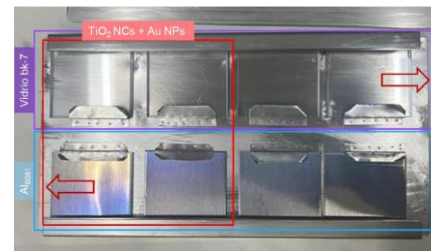
Validation to date

Pilot project with **Lidax Ingeniería**.

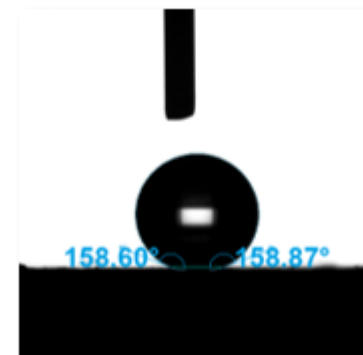
Samples intentionally contaminated with hydrocarbons and esters following ECSS-Q-ST-70-05C.

Two cleaning protocols: conventional bake-out (72 h, 80 °C, 10^{-6} mbar) and UV-assisted cleaning.

UV cleaning removed up to twice as much organic residue as bake-out, confirming photocatalytic self-cleaning capability.



Nanostructured coatings deposited on metal substrates (bottom) and optical glass (BK7) (top).



Superhydrophobic coatings.

Sensor success story: High-sensitivity sensors for IoT

Problem

Increase signal-to-noise ratio and sensitivity in miniaturized IoT sensors without damaging the base material of the devices.

Nanostine solution

Ultra-pure metal nanoparticles (Ag, Au) deposited directly onto active graphene or silicon substrates.

Commercial product in collaboration with Graphenea

Nanostine's MICS process deposits precision nanoparticles on Graphenea's graphene sensors.

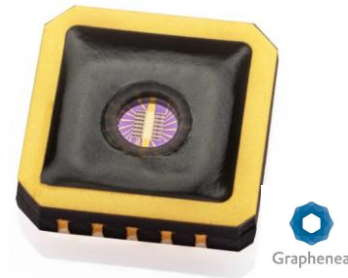
This functionalization **improves sensor sensitivity** to specific biological or chemical analytes without the contamination risks of wet chemistry.

Technology advantage (tailored functionalization)

Independent control: We can tune particle density (NPs/ μm^2) and particle size independently.

Benefit: This lets us maximize active surface area (increasing signal) without increasing individual particle size (maintaining resolution).

[Press release link](#)



Ultra-sensitive sensors.



Nanostine

The scalable way to do nanocoatings

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