NANOCOMPOSITE CERMET COATINGS FOR CSP TECHNOLOGIES DEPOSITED BY RF REACTIVE PVD ASSISTED WITH MICROWAVE ECR SOURCES

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High Temperature Air-stable Solar Selective Absorber Coatings for CSP receivers

All solar receivers need **high optical performance**

- **High solar absorptance** α_S to increase absorbed solar input $\alpha_S CI$
- **Low thermal emittance** $\varepsilon(T)$ to limit radiative thermal losses $\varepsilon(T)\sigma T^4$

→ High solar-to-heat conversion (heliothermal) efficiency

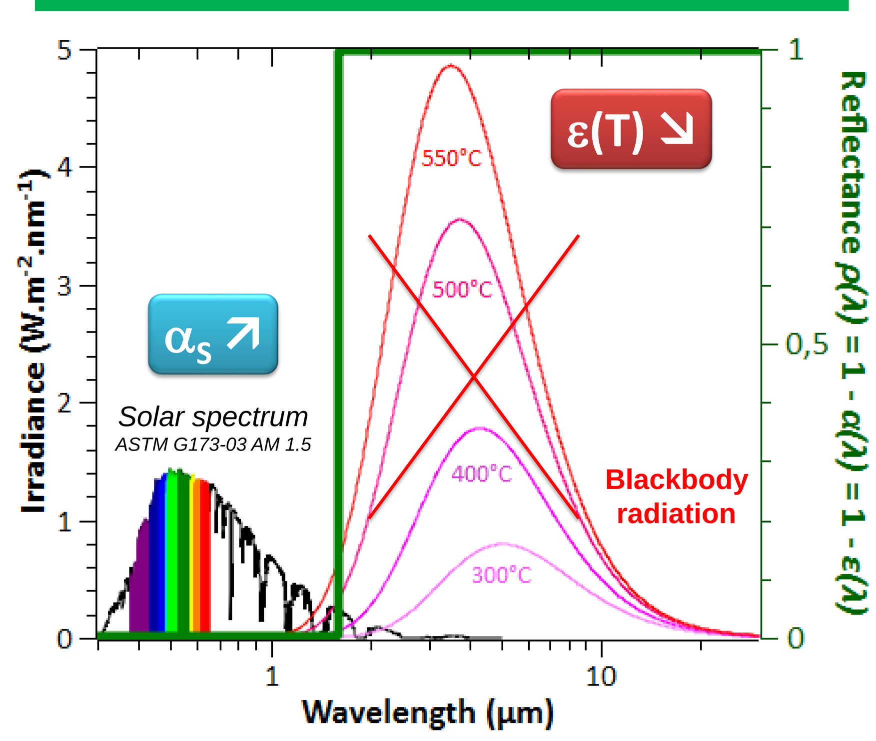
$$\eta_{heliotherm} \propto \alpha_S - \frac{\varepsilon(T)\cdot\sigma T^4}{C\cdot I}$$

→ Metallic pipes covered with **Solar Selective Absorber Coatings**

New generations also need **high thermal stability/durability in air**
i.e. **resistance or adaptation for long durations** to:

- high temperatures > 500°C → oxidation, atomic diffusion, etc.
- high thermomechanical stress & thermal shocks → fatigue, creep, etc.
- concentrated solar irradiance

Solar selective absorber coatings



For an ideal solar receiver, **spectral reflectance** $\rho(\lambda)$

- is low in solar range
- is high in IR range
- increases steeply at $\lambda_{cutoff} \approx 1.5 - 2$ µm (depends on T)

Complex behavior only achievable using **metal-ceramic coatings** (composites, multilayers)

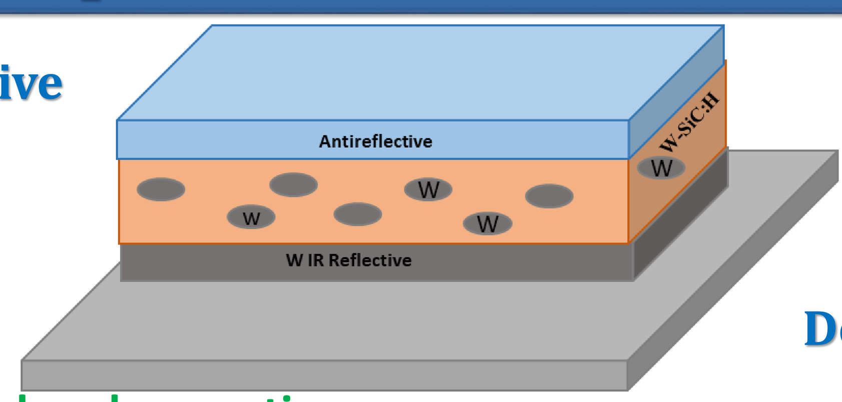
NanoPlaST project: Solar selective nanocomposite absorbers

"**Nano**composite **Pla**sma coatings for concentrated **S**olar **T**hermal energy conversion" (2019-2024)

This project funded by the French National Agency for Research (ANR) aims at developing **new nanocomposite absorber coatings** for CSP synthesized by vacuum plasma techniques, including **durability studies in representative working conditions**. Visit nanoplast-project.cnrs.fr

Step 1. : Design and modelization (COPS program)
Step 2. : First selection of materials (Solar performance, stacking optimization)
Step 3. : Second selection of materials (Feasibility, final stacking)

Project objective

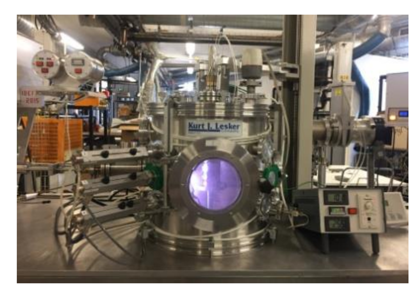


Solar selective absorber coating

- **W-SiCH nanocomposite absorber**
  - SiCH absorptive ceramic
  - W refractory metal
- Protective antireflective coating (ARC)

→ **High optical performance**
→ **High thermal stability/durability in air**

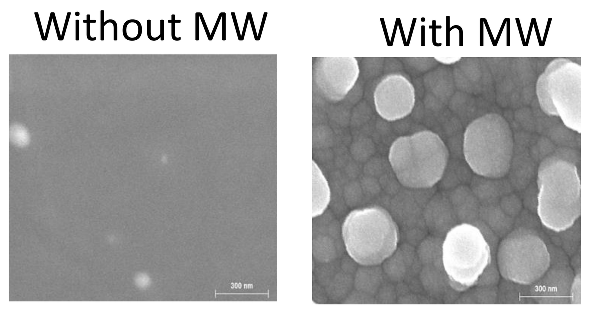
Deposition technique

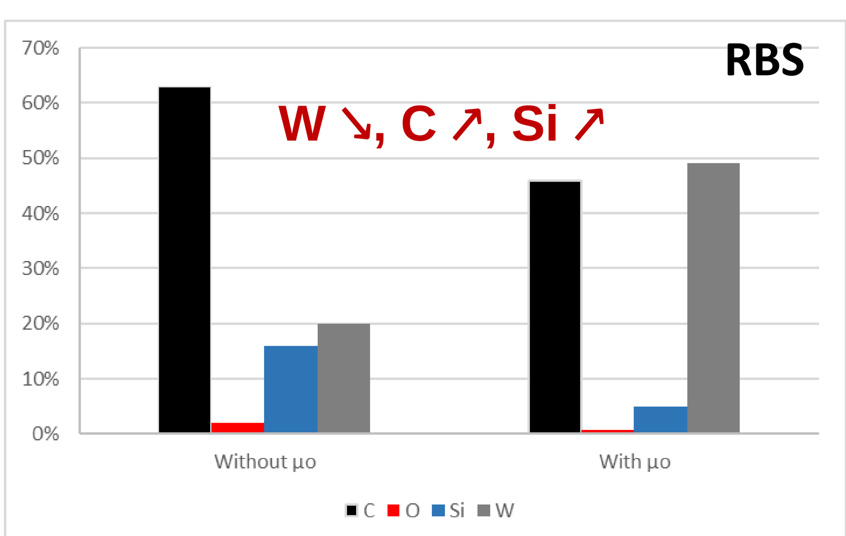


Vacuum plasma reactor
Reactive RF PVD (TMS + W)

Nanocomposite Cermet W-SiC:H

- Samples developed with 5 % of TMS (TetraMethylSilane)with and without microwave sources

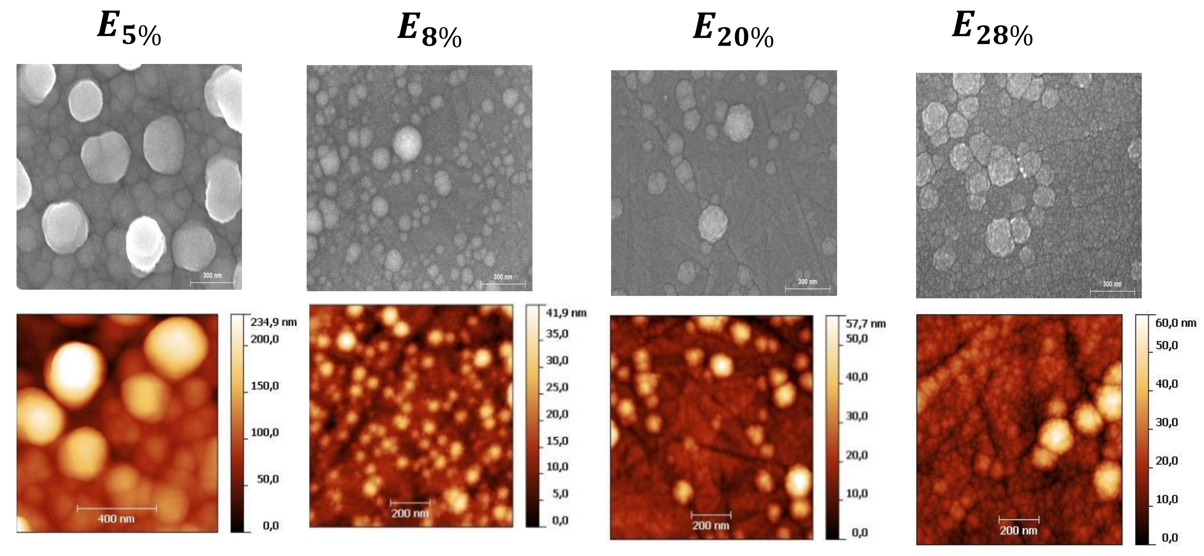




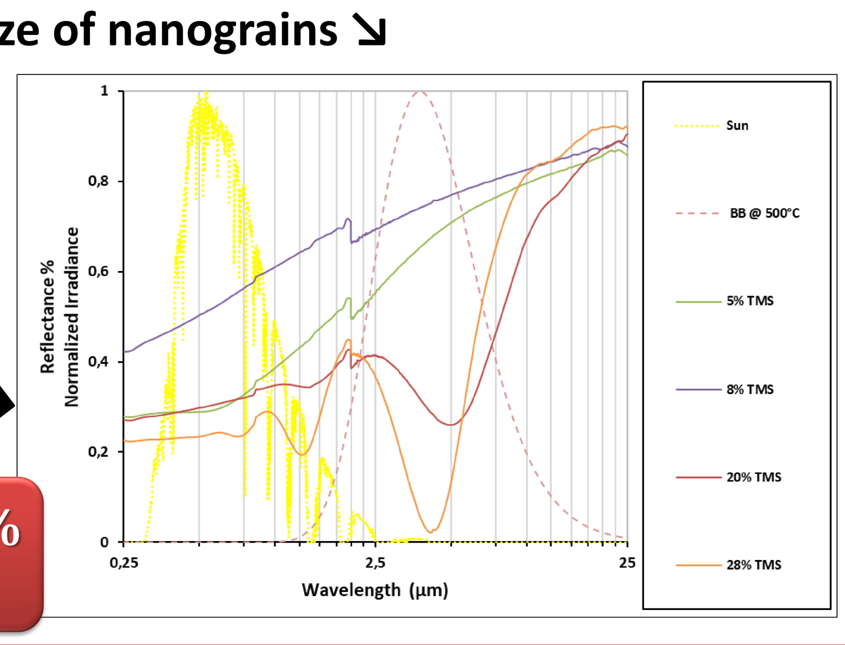
Effect of ECR MW sources :

- Target sputtering ↗
- Appearance of W grains

- 4 samples E_x with "x" the % of TMS



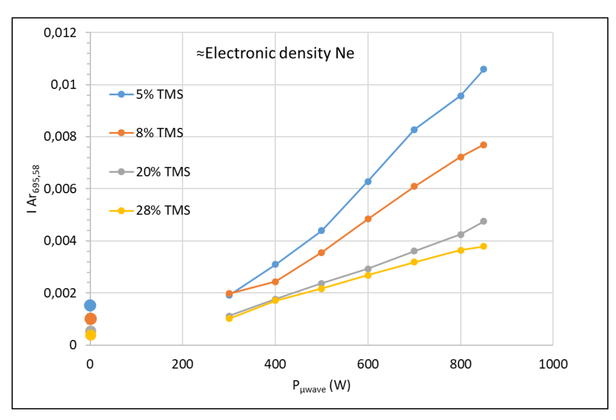
- Presence of nanograins containing tungsten
- **% TMS ↗ => size of nanograins ↘**

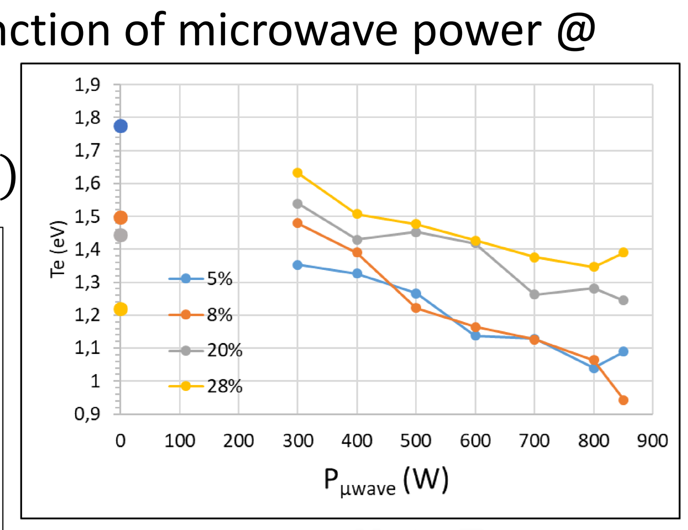


Sample with 20 % and 28 % of TMS are selective

Optical Emission Spectroscopy

- Estimated T_e and N_e as a function of microwave power @ different TMS flow rates
- Reference : H_α ($695{,}58\ nm$)

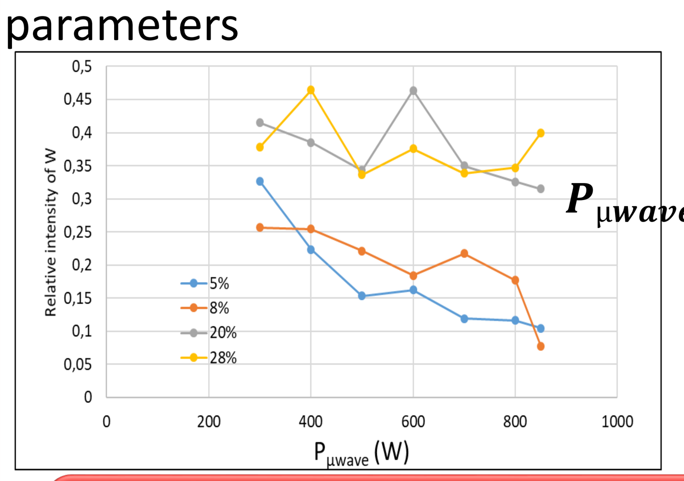




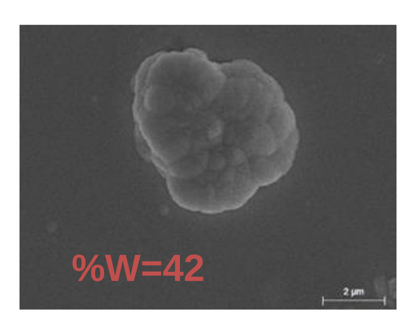
% TMS ↗ => N_e **↘,** T_e **↗**

$P_{\mu wave}$ **↗ =>** N_e**↗,** T_e **↘**

Effect of ECR MW sources : Significant modification in plasma parameters



$P_{\mu wave}$ ↗ => W ↘



SEM image of powder collected after deposition

W detected in coating but not in plasma phase --> formation of powders undetectable by OES

Conclusions and further work

- Plasma deposited (W, SiCH) solar selective absorber coatings with good optical performance and thermal stability in air at 500°C were developed for CSP technologies.
- W-SiCH nanocomposite absorbers are optically selective.
- Their insertion in multilayers containing W IR-reflective sublayer and SiC antireflective top layer could lead to good optical performance as solar absorber.

This work was supported by the French National Agency for Research (ANR) under Investments for the Future program (awards ANR-10-LABX-22-01-SOLSTICE & ANR-10-EQPX-49-SOCRATE) and NANOPLAST project (ANR-19-CE08-0019-01 (nanoplast-project.cnrs.fr)), and by the French Région Occitanie and European Regional Development Fund FEDER (Vadum-CSP and PLASMECO projects).