Photonic Metaconcrete with Infrared RAdiative Cooling capacity for Large Energy savings (MIRACLE)

MIRACLE
Photonic Concrete

MIRACLE IN A NUTSHELL

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GA 964450

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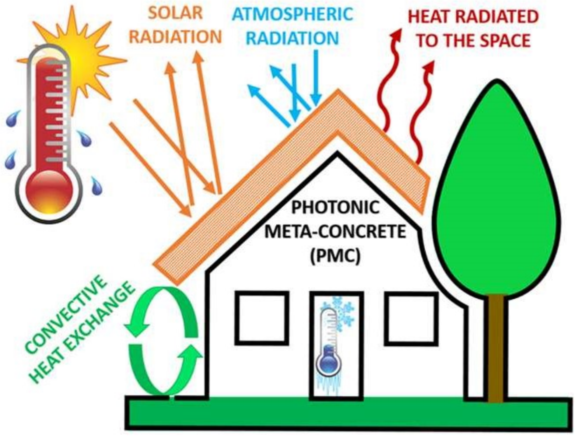
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 964450.



The MIRACLE project *opens a radically unexplored scientific and engineering avenue*, i.e. the concept of Photonic Meta-Concretes (**PMC)**, and endeavours to

(1) prove the feasibility of this idea by developing for the first time in the state of the art a radiative cooling device based on a PMC

(2) **fabricate a prototype** whose radiative cooling performance will be validated on the roof of a real building and

(3) **start the roadmap** of this emerging S&T avenue (PMC) by evaluating its potential environmental impact and exploring how the PMCs could be used in other applications.

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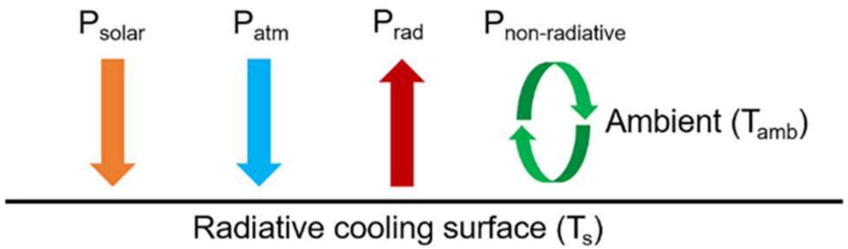
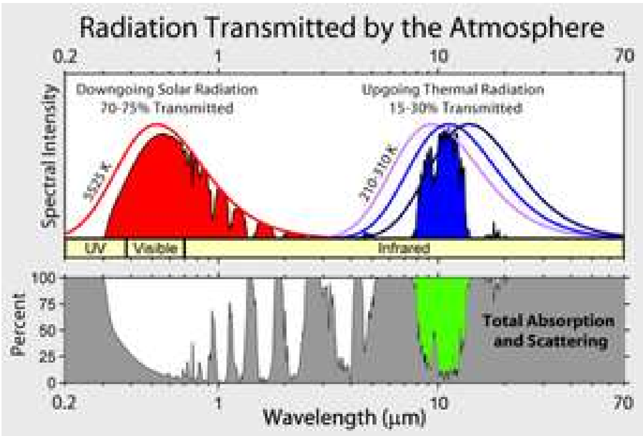
RADIATIVE COOLING TECHNOLOGY





- All bodies in the Earth are in continuous exchange of energy with the sun and the atmosphere, with a **net balance of power** that depends on the incoming solar (short wave) and atmospheric radiation, the emitted thermal radiation and non-radiative heat exchanges.

- Unfortunately the atmosphere works like an opaque shield in most of the thermal radiation wavelengths **(greenhouse effect!)**

- **Radiative cooling** technology utilizes the atmospheric transparency window (**8-13 mm**), called **Atmospheric Window (AW)**, to passively dissipate heat from the Earth to outer space.

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RADIATIVE COOLING TECHNOLOGY

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In theory, easy…

"Easy" recipe for daytime applications….

- Maximize the solar reflectance
- Maximize the emissivity in the AW
- Minimize the non-radiative loss

In practice, quite complex

- Technologically unfeasible until the advent of photonic meta-materials.
- 1st proof of concept in 2014!
- Current solutions are based on either **Meta-materials** or on **Hierarchical porous materials.**

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CONCRETE is the most used material, very available and…

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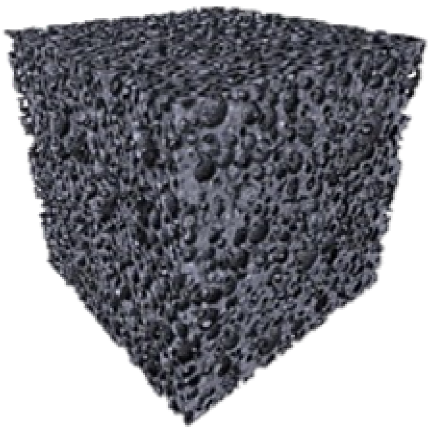
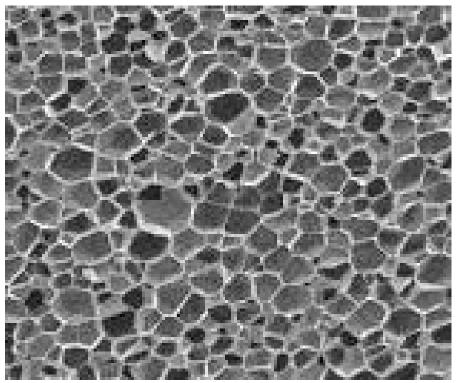
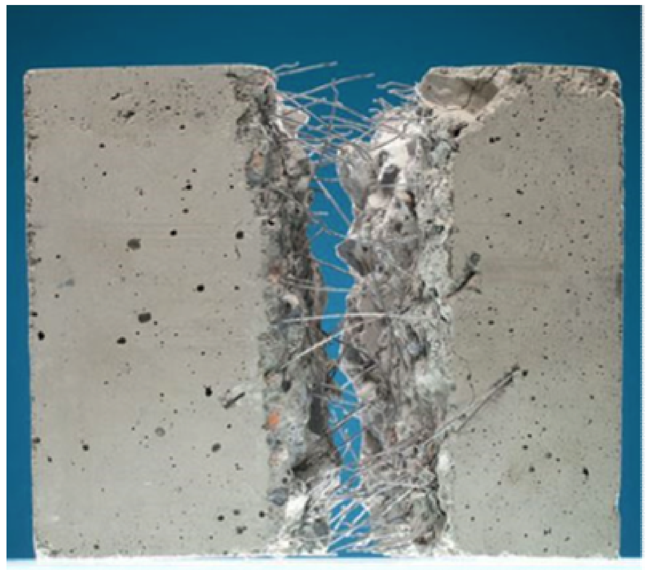
INTRINSICALLY HIERARCHICAL POROUS STRUCTURE





OFTEN REINFORCED BY MICROFIBRES



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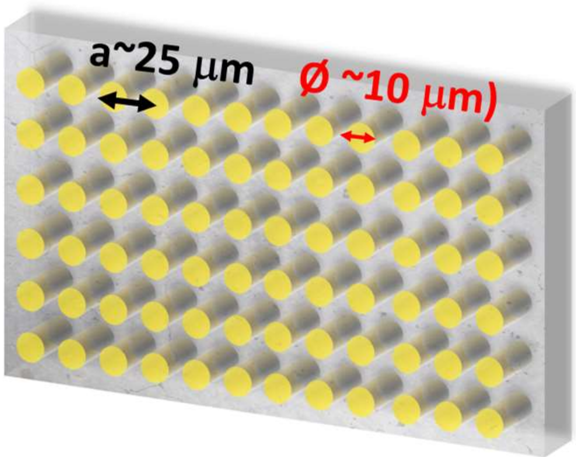
PHOTONIC META-CONCRETE

Based on an **ordered arrangement** of the steel microfibres that work in combination with the hierarchical porous structure of concrete.



- Cheap & scalable, and not “convection shields”
- Large impact
- Sound from a materials point of view

- Tunable composition
- Tunable porosity

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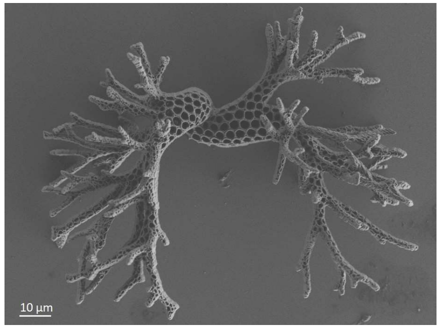

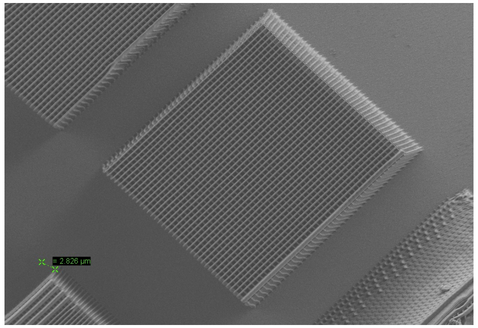

Implementation by

- **advanced optimization** methods based on deep learning technologies at the design level
- **inverse-phase fabrication methodology**

(micro-patterned concrete moulds will be produced by two-photon polymerization technology (2PP)

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Agencia Estatal Consejo Superior de Investigaciones Científicas SPAIN

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