SIO_2 Embedded Poly-methylpentene

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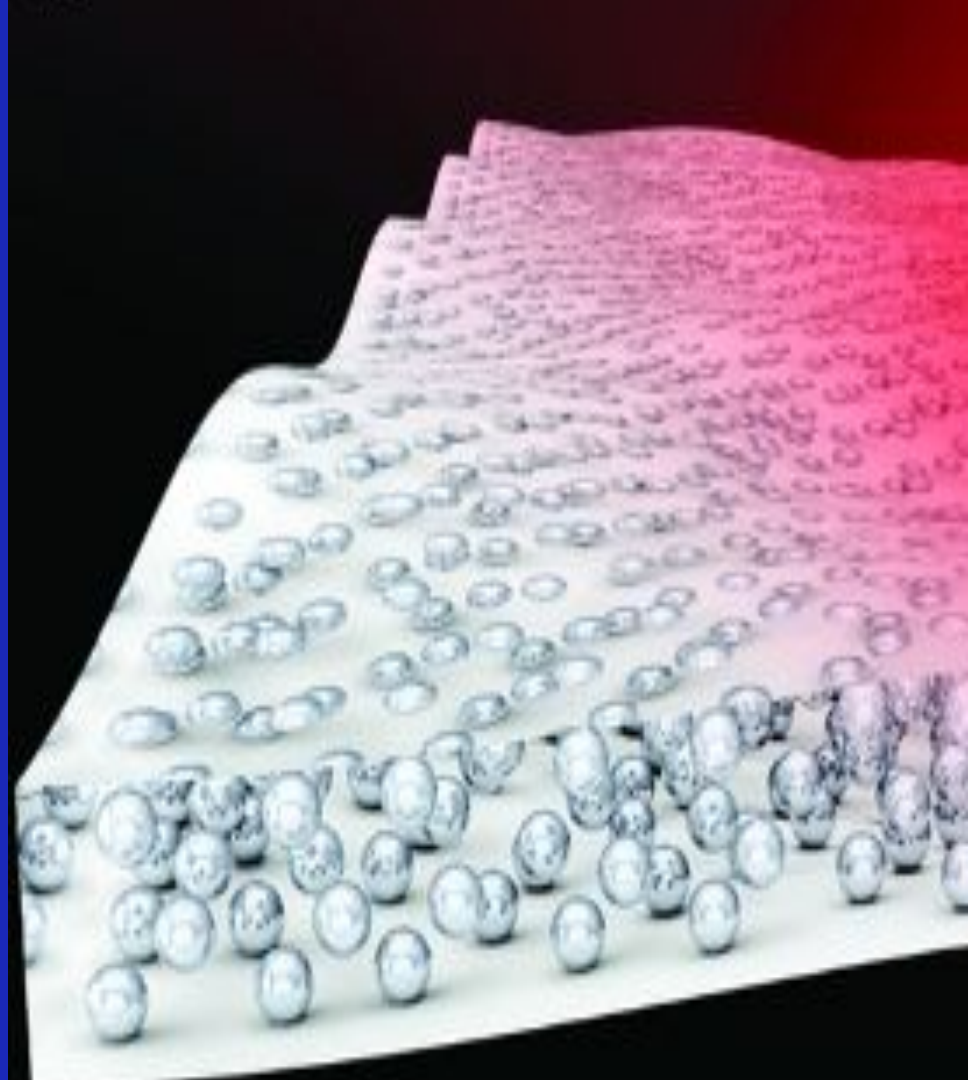
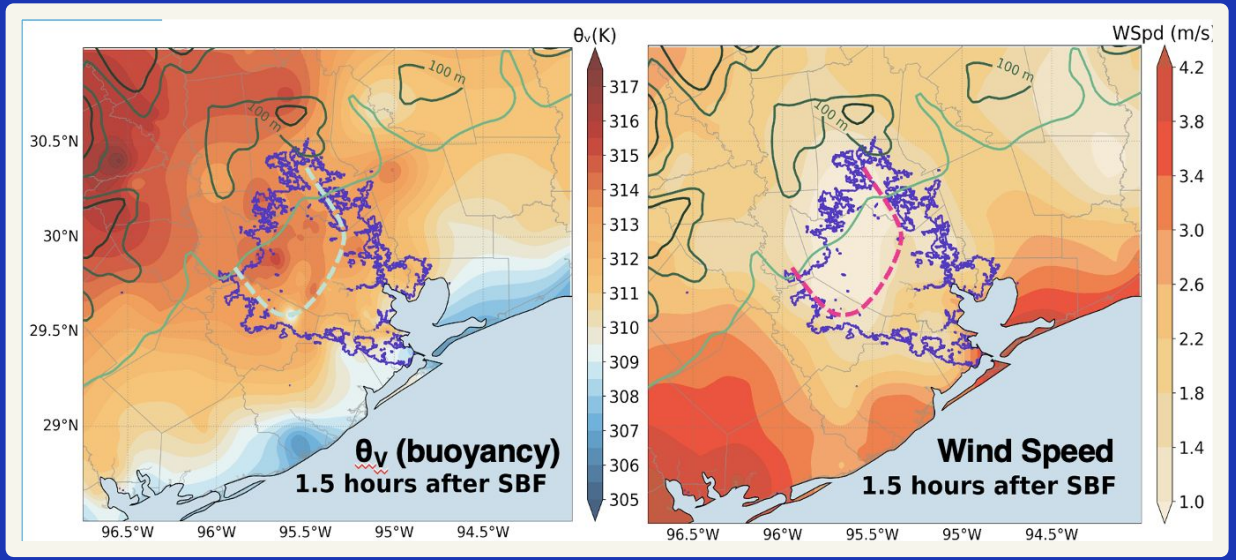


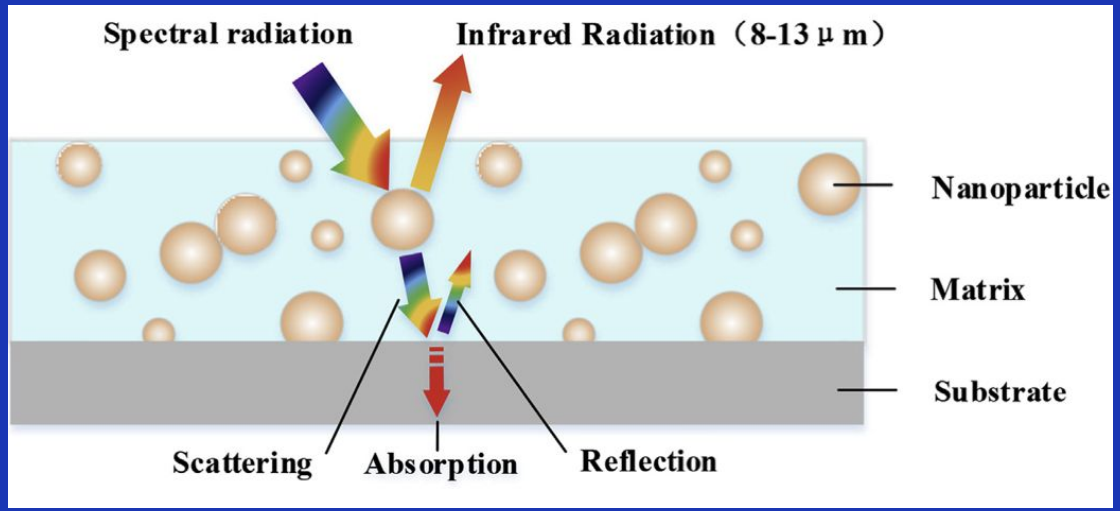
Problem Statement

Thermal gradients of cities affected by the advent of UHI effects, providing need of diurnal cooling without the use of energy



UHI effect on SBF propagations in Houston. Virtual potential temperature (left) and Wind speed (right).

Radiative Sky Cooling

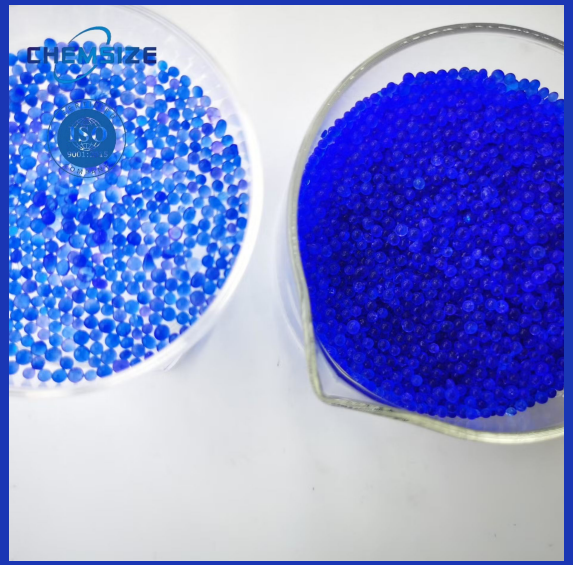


Schematic of radiative transfer for cooling coating with SiO2 particles. ref

Passive cooling method emits into atmospheric transparency window and has low absorption of thermal infrared radiation in the solar spectrum.

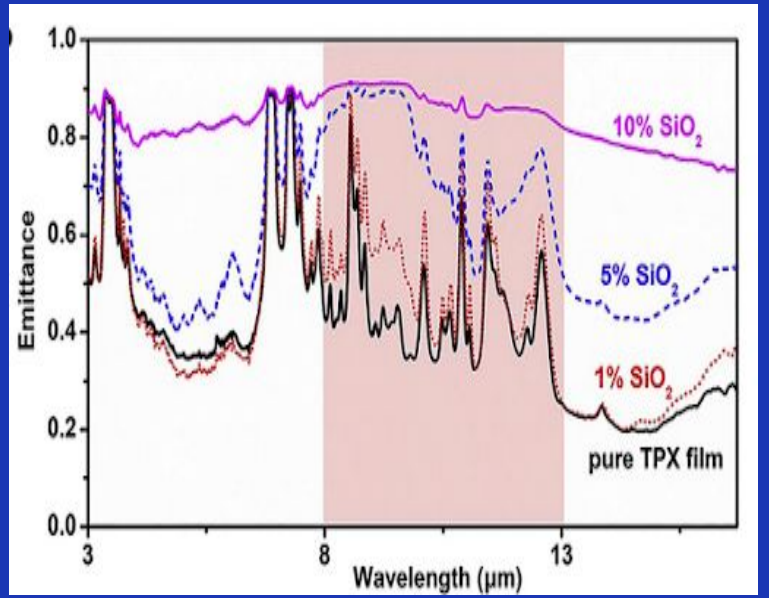
Material Properties

- Hybrid film contains Silica microspheres, a silver lining, and the TPX.
- General Properties of Silica
  - High Compressive strength
  - Brittle
  - High strength to density ratio
  - High melting point.



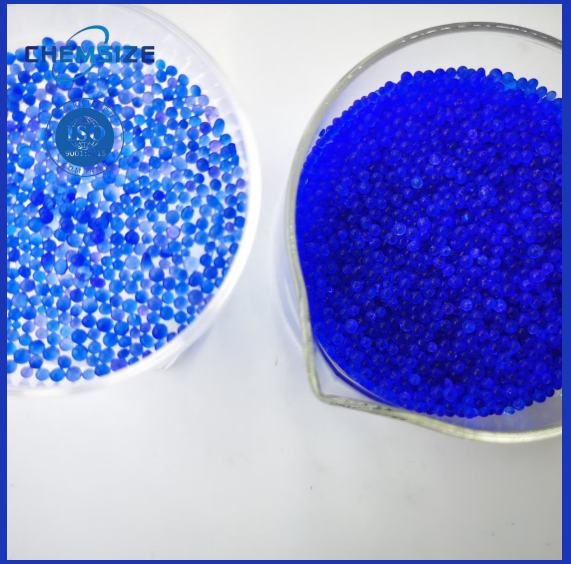
Optical and thermal properties of Silica

- Allows visible light to pass through (low absorption in the visible spectrum)
- Exhibits infrared absorption and efficient thermal emission at 8 µm and 13 µm.
  - 10% concentration of silica to TPX displayed the highest emittance.
- Strong scattering and emission properties
  - The scattering efficiency is highly dependent on the particle size of silica
  - Optimal radius 75-275 nm comparable to the wavelength of the incident light.



Properties of TPX

- The TPX matrix used in the film serves the purpose of introducing plasticity into the hybrid material.
- Thermoplastic polymer
- Low density and light weight
- Heat resistance
- Low cost
- Acts as a binder for silica microspheres
- Adds plasticity to the hybrid material for easy film formation.

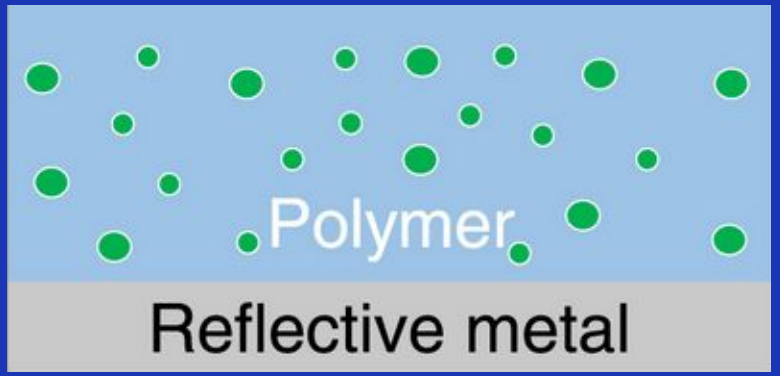


Properties of Silver Ag

- Reflectivity: 97%, one of the highest among metals
- Reflects significant solar radiation, reducing heat absorption
- Assembled at the bottom to radiate off any wavelengths that may have made it through the layer of TPX and silica microspheres.

Microstructure

- Silver Coating
- TPX (Polymethylpentene)
- Silica Microspheres



Randomly Distributed Particle Structure. ref

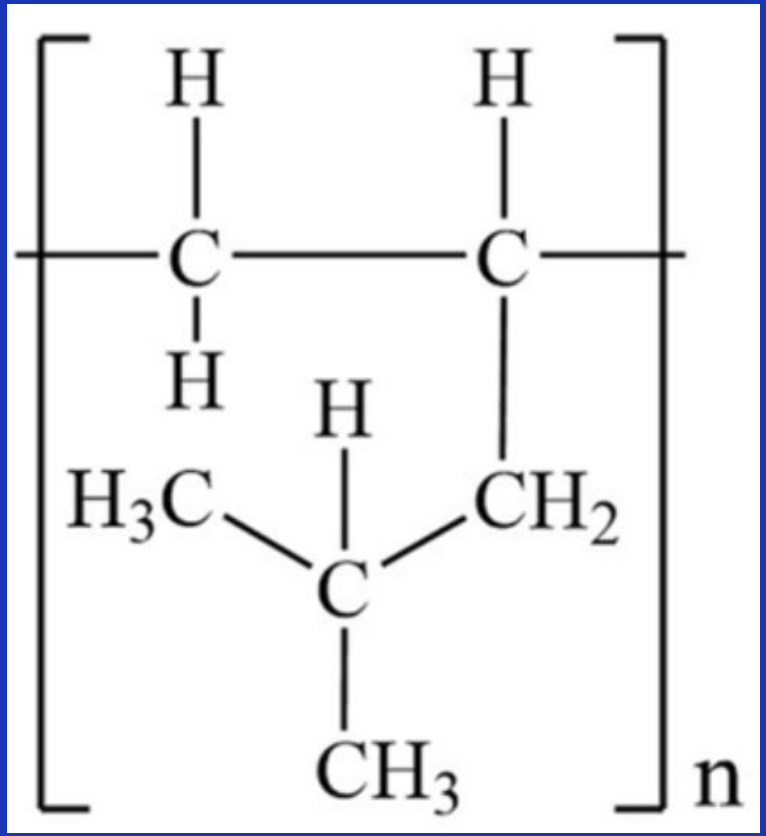
Silver Coating

- Single Valence Electron
- Face-Centered Cubic Structure
- Full d-subshell

Silver Crystal ref

TPX

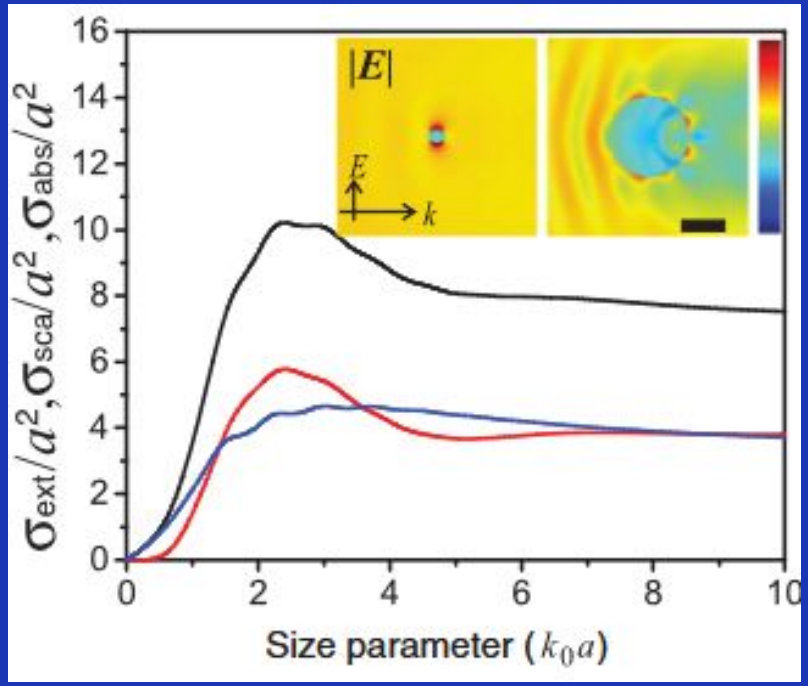
- Linear structure
- Isotactic Stereochemistry
- Semicrystalline



Polymethylpentene Repeat Unit ref

Silica

- Quasiparticles — Phonons & Polaritons
- Dipole Resonance
- Peak at Size Parameter of 2.5, determined experimentally



Normalized Absorption, Scattering, and Extinction.
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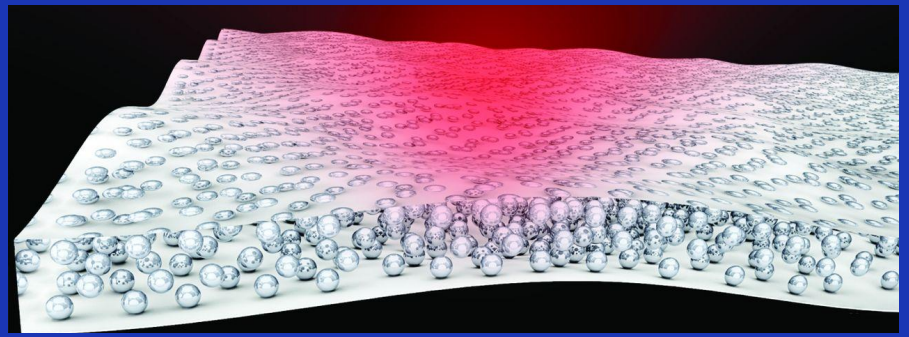
Composite

- Randomly distributed particles
- Thin semicrystalline film
- Thin reflective coating



Material Schematic
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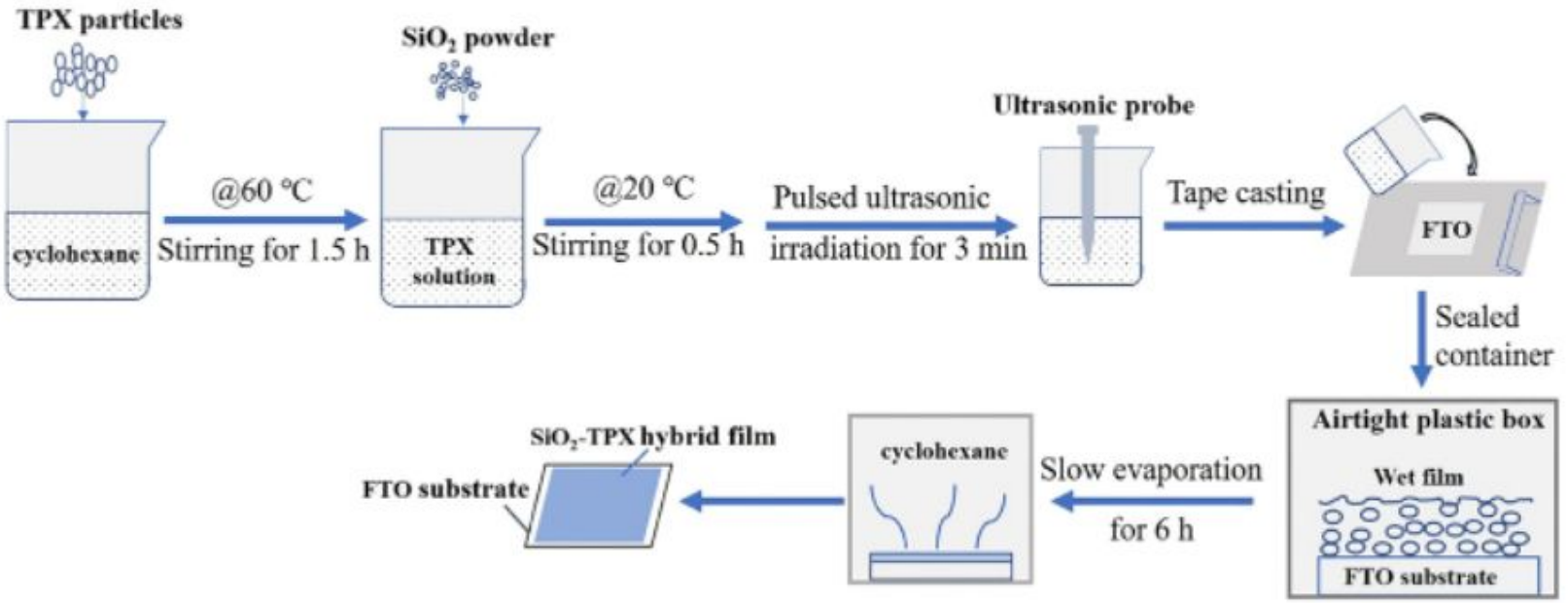
Processing

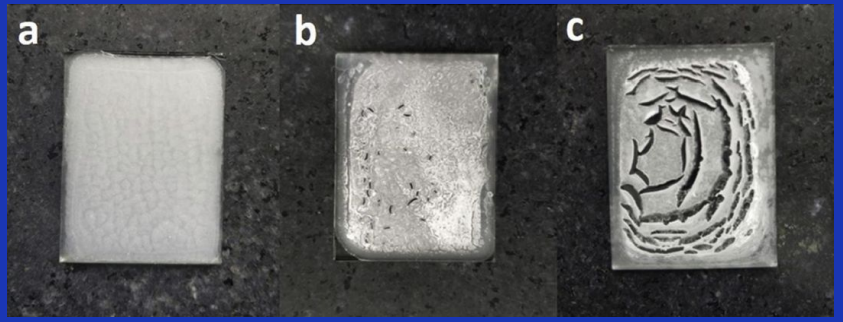
Tape Casting



Preparation process of SiO2-TPX hybrid films via the tape casting method ref

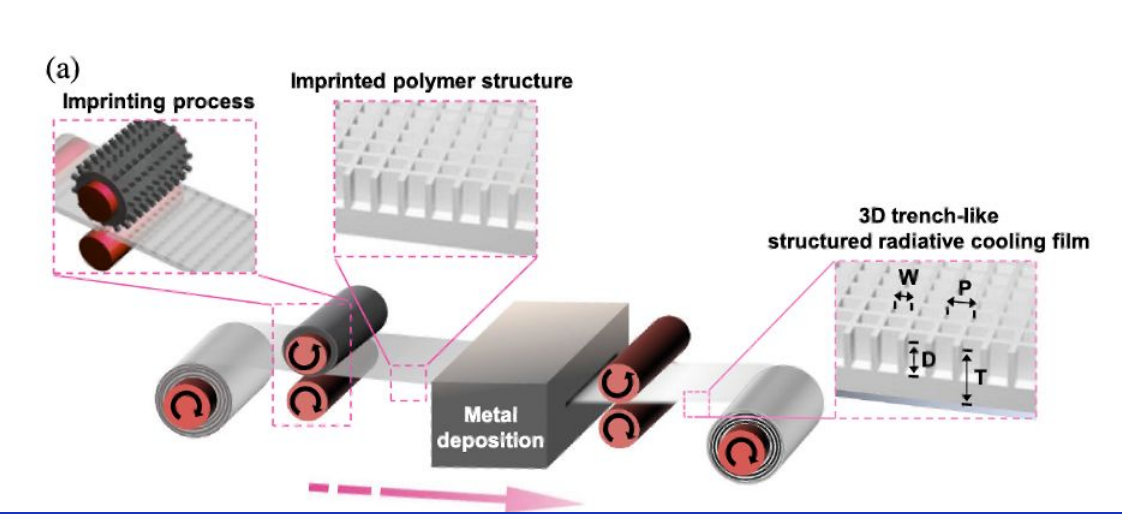
Tape Casting

Tape casting uses a slurry of TPX and silica spread onto a surface to create thin, precise films.
It is ideal for thin, large-area films but is slower and more labor-intensive than roll-to-roll printing.



Preparation of silica-TPX with (a) ultrasonic irradiation with sealing (b) without ultrasonic irradiation (b) without ultrasonic irradiation nor sealing ref

Roll to Roll Printing (R2R)

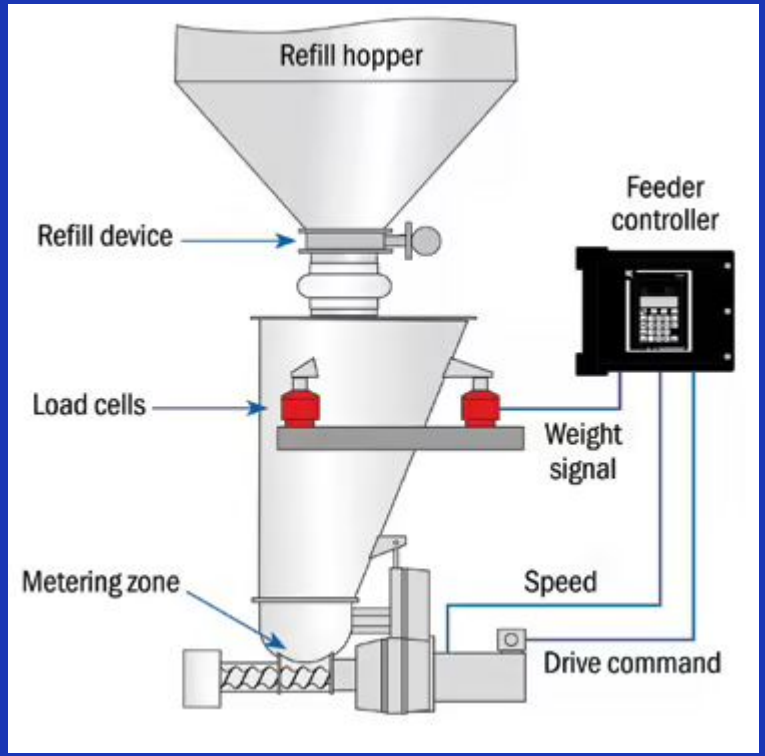


Continuous manufacturing process where materials are printed onto a flexible substrate

roll-to-roll manufacturing processes for preparing 3D structured polymer metamaterial radiative cooling (PMRC) film. ref

Roll to Roll Printing (R2R)

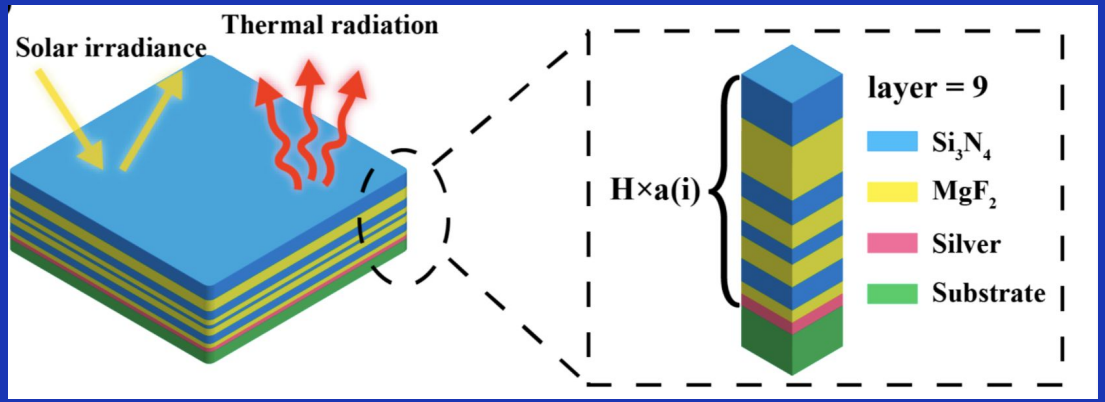
Method that can produced uniform distributions of Silica sphere by utilizing a gravimetric feeder.



Gravimetric Feeder set up ref

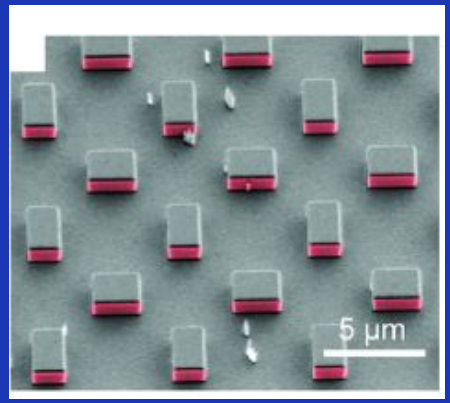
Alternative Materials

Multilayered Structure



Schematic of a multilayer radiative cooling coating ref

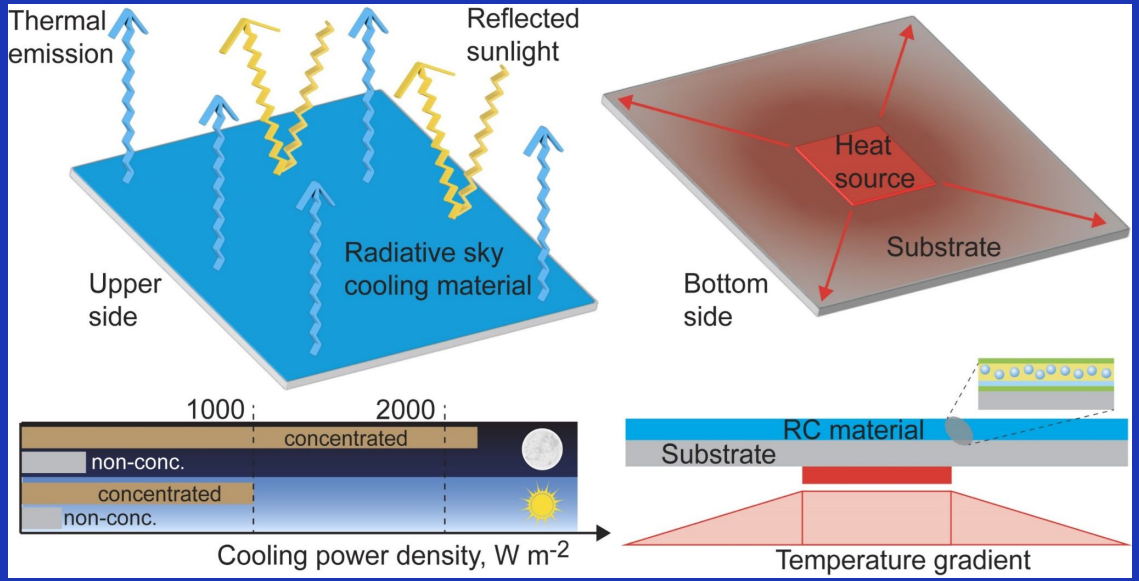
Nanofabricated Metamaterials



Metal loading film ref

Applications

Building Surfaces

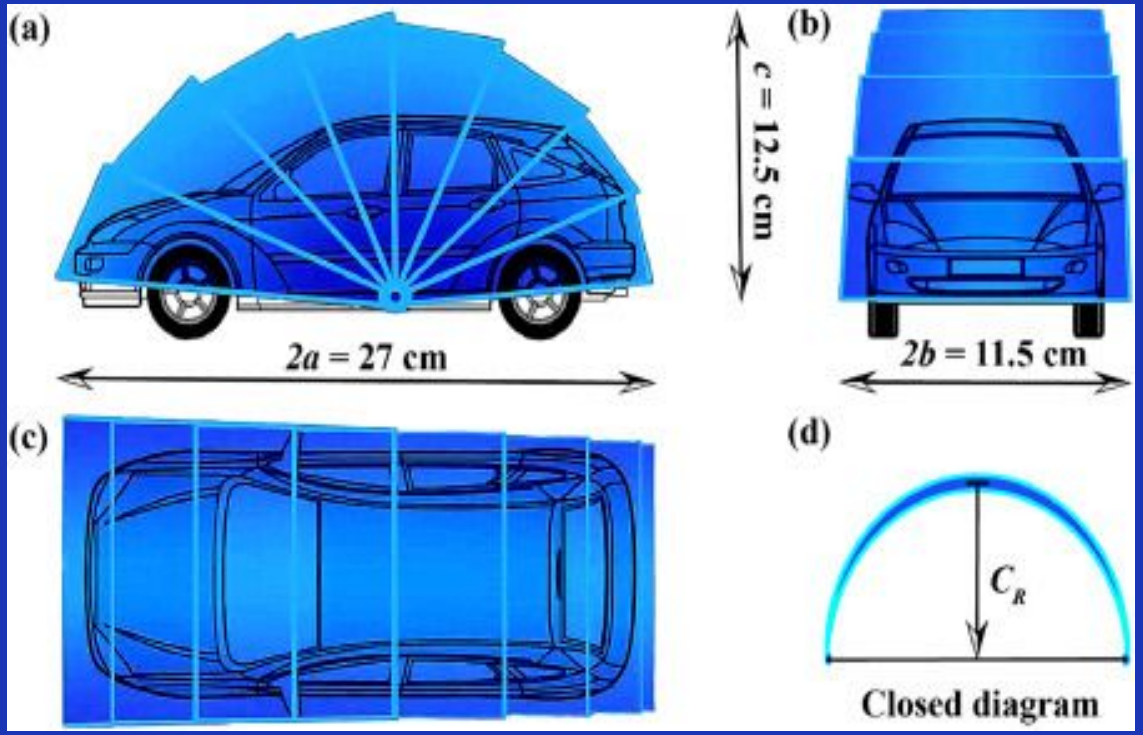


Radiative Sky Cooling Material on Rooftop ref

Application of Silica-TPX on rooftops and building facades for passive indoor temperature reduction.

Vehicle Surfaces

Application of Silica-TPX on vehicles to prevent overheating



Radiative Cooling Covers for Automobiles ref

Solar Energy Applications

Application of Silica-TPX on Solar Cells to minimize efficiency losses caused by overheating

Solar Cells on Building Roof ref

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