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Poster n°68

A dynamic passive thermoregulation fabric using metallic microparticles

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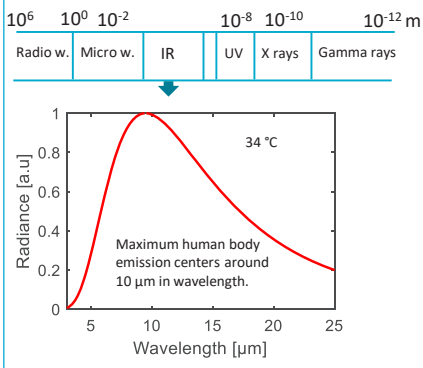
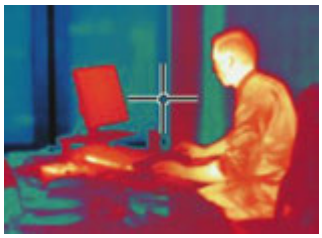
Radiative heat transfer accounts for more than 50 % of heat dissipation from the human body in an office situation. Therefore, with proper radiative thermal management, one can tailor and design passive temperature regulating textiles. This can lead to a novel way to decrease energy consumption in buildings.

Motivation

Human body heat loss distribution in an office situation



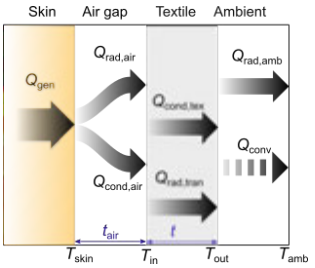
Radiation ($Q_{rad} > 50$ %)



Conduction ($Q_{cond} < 30$ %)

Convection ($Q_{conv} < 10$ %)

Thermal comfort means:
Metabolic heat generation = Heat loss

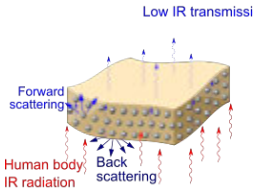


$$Q_{gen} = Q_{rad} + Q_{cond} + Q_{conv}$$

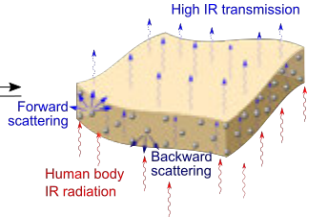
Design Working Principle

Particle volume fraction determines IR transmission/reflection

Heating mode (Cold)



Cooling mode (Hot)



At a lower temperature
- Polymer shrinks.
- Particle volume fraction increases.
- High IR reflection in human emission wavelength range.

At a higher temperature
- Polymer expands
- Particle volume fraction decreases.
- High IR transmittance in human emission wavelength range.

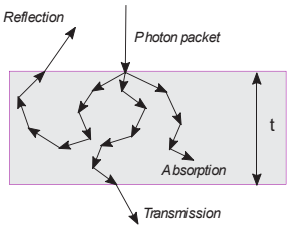
Methods

Electromagnetic and radiative transfer calculations

Single silver particle:
Lorenz-Mie theory

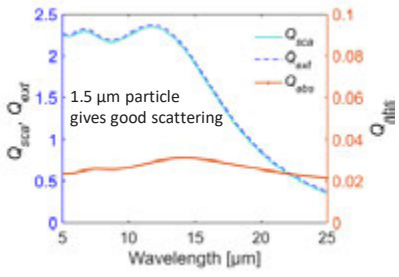
Silver particle cloud:
Independent scattering

The whole fabric structure:
Monte carlo simulation

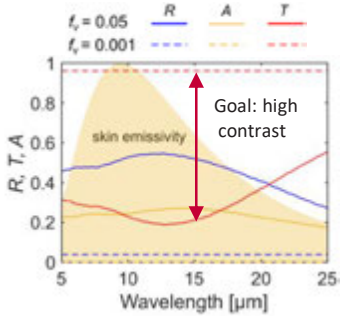


Results

Scattering (Q_{sca}), Absorption (Q_{abs}), and Extinction (Q_{ext}) coefficients

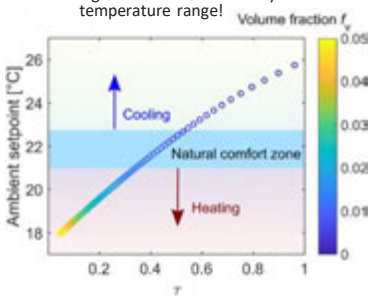


Reflection (R), Transmission (T), Absorption (A), and volume fraction (f_v)



Which temperature is comfortable:
Ambient setpoint temperature

Our textile gives comfort over a very wide temperature range!



The combination of thermo-responsive shape memory polymer and metal microspheres modulates IR transmission to enhance user comfort. This novel design keeps a person comfortable in a large temperature range, so less heating and cooling of the office is required.

[1] Zhang *et al.*, *Science* **363**, 619–623 (2019).
[2] Peng, Y. *et al. Nat. Sustain.* **1**, 105–112 (2018).

Support from Interreg project PHOTONITEX

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