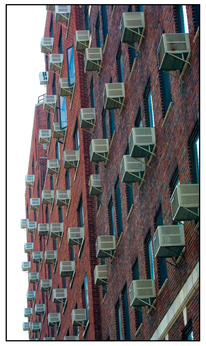
Plasmonic Paint for Energy-Efficient Coatings

S. McCormack, P. Cencillo-Abad, D. Chanda

NanoScience Technology Center, Department of Physics, CREOL, College of Optics and Photonics, University of Central Florida, Orlando, FL, USA

Abstract

Sustainability is not a goal but a requirement. Over 10% of US energy-consumption is employed in space cooling, spending more than $70B and producing CO2 emissions above 360M tons yearly[1].

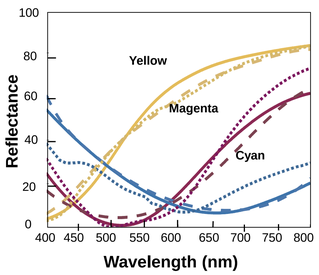


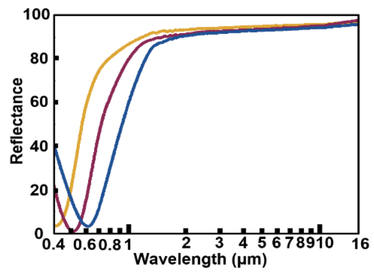
Solutions for space cooling rely on AC systems that generate further heat waste. On average, this is responsible for about 5% of the temperature in cities. Research focus has shifted from efficient cooling technologies to more energetically efficient materials that reduce the need for cooling altogether. In particular, in the use of heat-insulating coatings has shown promise for its versatility and lower cost.

We present a functional nanostructured coating for colored heat-shield. With low-cost and eco-friendly techniques, the smart coating will maintain temperature of painted surfaces reducing energy waste.

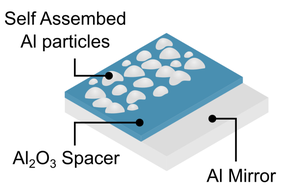
A Cool Paint

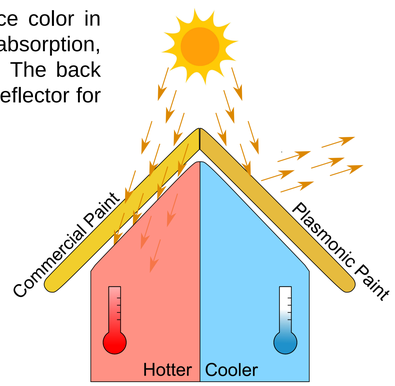
Producing thermally reflective paint is indeed a viable means of keeping objects cool and thereby saving energy.





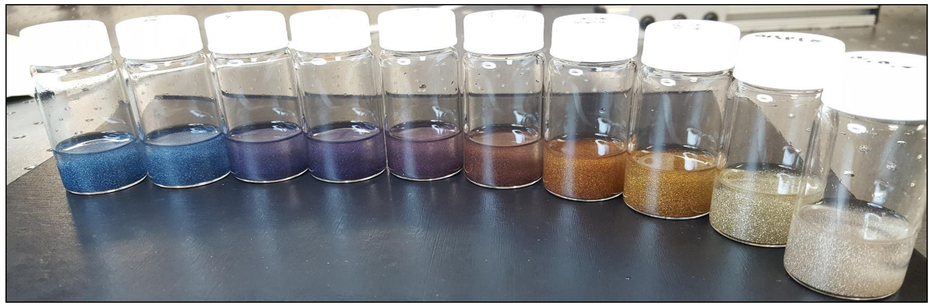
While the nanoparticles produce color in the visible through plasmonic absorption, they are transparent in the IR. The back mirror is however a very good reflector for IR radiation.

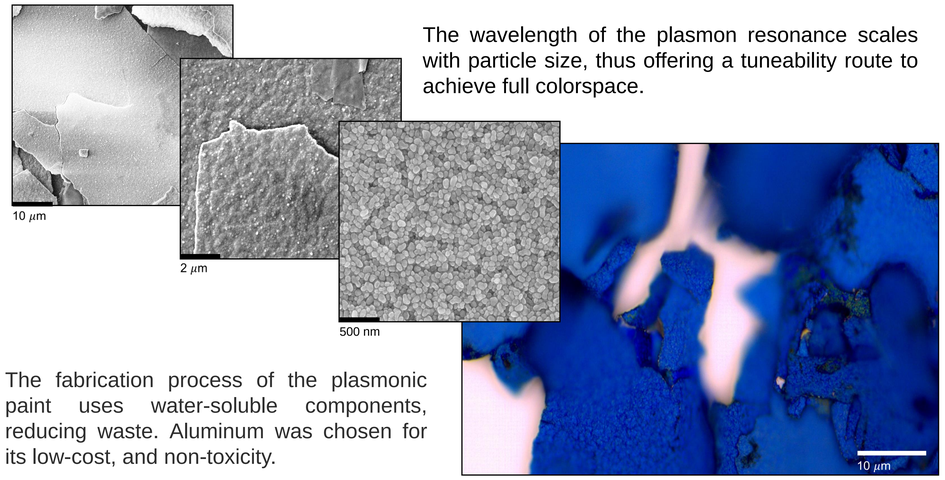




In this study, a paint that produces a discernable color while being highly reflective in the atmospheric window is studied as an innovative solution to achieving energy efficiency without sacrificing aesthetics.

Structural Plasmonic Paint





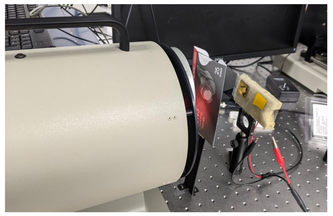
The wavelength of the plasmon resonance scales with particle size, thus offering a tuneability route to achieve full colorspace.

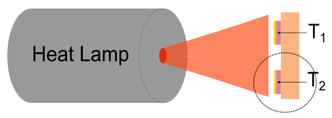
The fabrication process of the plasmonic paint uses water-soluble components, reducing waste. Aluminum was chosen for its low-cost, and non-toxicity.

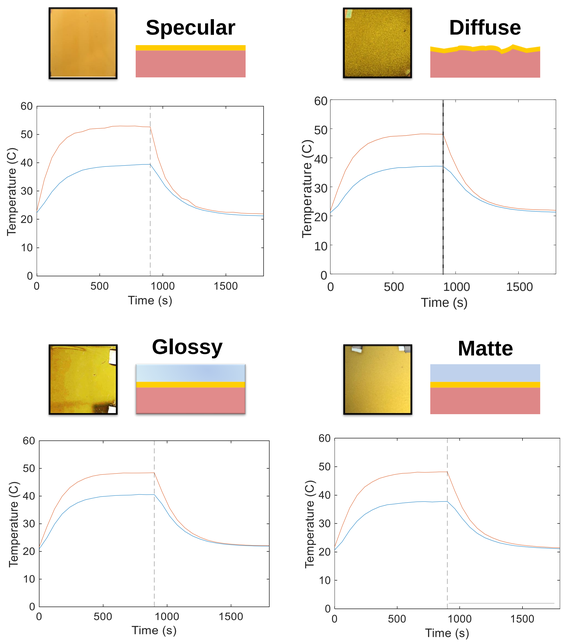
A Versatile Platform

We compared glass coated with both commercial and structural paint under IR illumination. The samples were heated and cooled for 15 minutes, and temperature was tracked.

2 color modes are studied: specular (flat, glossy coat), and diffuse (micro-corrugated and matte coat).

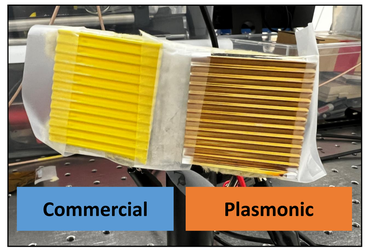


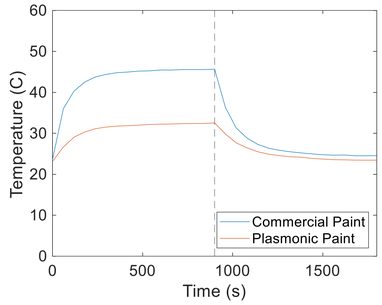




Real World Application

Integration of this thermally reflective plasmonic paint can play a crucial role in house insulation. A piece of metal roofing was coated in plasmonic paint and compared to commercial paint to show the viability of the architecture.





We observe a difference over 12.2°C (27 °F) between the commercial paint and the plasmonic coating.

Corrugated sheets of metal provide a realistic bench test. Their widespread, durability, and low-cost makes them a practical choice for many building solutions from agriculture, to commercial buildings and housing.

Conclusions

Reducing energy waste by increasing the efficiency of existing buildings presents a formidable challenge. Solutions relying on heat gain control have received great attention in recent years for their promise. In particular, cooling coatings offer an affordable and reasonable alternative to AC systems for space cooling.

We present a nanostructured plasmonic paint, as an effective heat-shield coating. The paint reduces infrared heating of objects, offering almost 100% protection from NIR and MIR bands (2um – 16um) corresponding to the atmospheric window. When compared to other commercial solutions the nanostructured paint kept coated objects above 10°C (20 °F) cooler. Importantly, the paint remains efficient while offering a wide range of bonding substrates, and even protective coatings.

In summary, the plasmonic paint paves the way for a more green-future, offering a low-cost, environmental friendly, and aesthetic solution, to higher energy-efficiency.

References

[1] United States Environmental Protection Agency: https://www.epa.gov/rhc/renewable-space-cooling

Acknowledgements

DUKE ENERGY®

UCF The Center for Initiatives in STEM