Ultra-Cool Metal Roofing Material is Poised to Reduce Energy Needs

Place something in the sun, and it will heat up. The use of a reflective window shade in a car is a common way to prevent the interior from getting hot due to incident sunshine. Similarly, a building's light-colored roof heats up less than a dark roof, but both can get much hotter than ambient air temperature.

According to the U.S. Energy Information Administration (EIA), about 40% of total U.S. energy consumption in 2020 occurred in residential and commercial buildings. Cool roofing materials have the potential to reduce energy bills by decreasing air conditioning needs, extend service life by decreasing roof temperatures, and lower peak electricity demand, says the U.S. Dept. of Energy.

With funding from the National Science Foundation (NSF), PC Krause and Associates (PCKA) developed a passive radiative metamaterial that can serve as an economical, ultra-cool metal roofing product. A roof coated with such a novel metamaterial could stay remarkably cooler than its surroundings by radiating heat back past the Earth's atmosphere into space. Such coated roofing surfaces could have a transformative impact on energy costs for residential and commercial buildings.

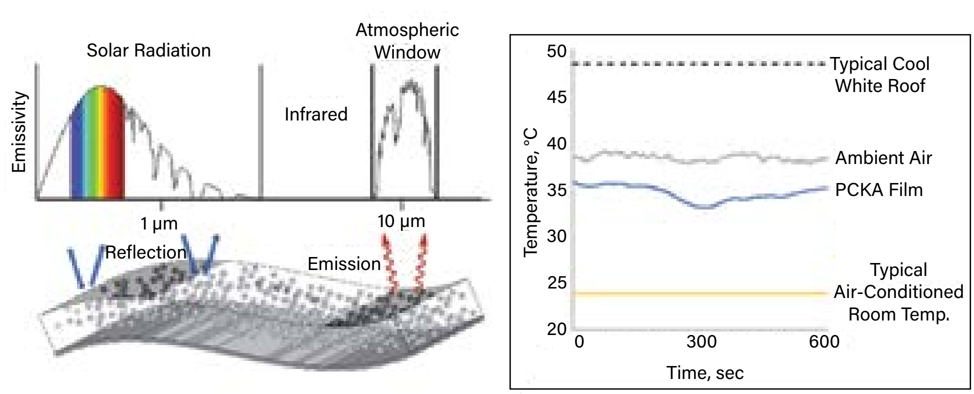
The technology required the creation of a film designed to absorb incident solar energy and emit it back at wavelengths within the atmospheric window, a range of wavelengths at which radiation does not heat atmospheric gases. This unique radiation band allows the material's thermal energy to escape to the cold heat sink of outer space without interacting with the atmosphere. If the amount of radiation emitted in this band is greater than the amount absorbed from the sun, the equilibrium temperature of the material will be lower than the ambient air temperature, and up to 20°C lower than the best available cool roofing products on the market today.

PCKA's cool roofing film consists of a UV-stable polymer resin embedded with solid silica microspheres. The polymer resin is commercially available, and the silica microspheres were selected to emit energy specifically in the atmospheric window. When coated onto a reflective metallic substrate, the spectrally selective film is able to radiate energy out of the structure, resulting in heat removal and subcooling of the surface relative to its surroundings. The durability and longevity of metal roofing has contributed to its sharp rise in market share over the past decade, making it an ideal medium for PCKA's film. With a passive cooling capability up to 100 W/m^2 in direct sunlight, PCKA's film offers technical solutions for new structures with high cooling requirements, and energy efficiency upgrades for existing installations.

With the potential to passively cool roof surface temperatures below ambient temperature in direct sunlight, PCKA's composite film could provide significant energy savings relative to commercially available roofing products. PCKA has also developed a novel scalable manufacturing approach to produce the films.

Prototype ultra-cool roofing panels were evaluated at the Univ. of Texas at Austin Center for Energy and Environmental Resources on instrumented test buildings alongside commercially available cool white roofing. Roofing panels equipped with PCKA's film were observed at temperatures 10°C cooler than high-end white panels in direct sunlight, demonstrating a step change in thermal performance.

"With its low cost and substantial energy benefits, passive radiative cooling offers a large return on investment for both new construction and aftermarket applications. PCKA is excited to be at the forefront of this revolutionary technology," says PCKA President Eric Walters. CEP



▲ PC Krause and Associates (PCKA) developed a novel metamaterial that can reflect incident solar energy and emit thermal radiation at wavelengths within the atmospheric window. The graph on the right shows the surface temperature of the PCKA film coating, which is below ambient air temperature.

This technology was funded through the NSF Small Business Innovation Research (SBIR) Program.

This article was prepared by the National Science Foundation in partnership with *CEP*.