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Enhancing Radiative Cooling Power Using Ultra-Broadband Near-Unit Spectrally Selective Thermal Emitters Based On Metamaterial Structure.

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Abstract
Today, high energy consumption and thermal energy management are becoming crucial for sustainable stable environment. Recently, passive radiative cooling (PRC) has gained attention since it is one of the innovative strategies for reducing energy density in the environment without requiring any energy consumption. By selectively absorbing ultra-broadband infrared and properly reflecting solar irradiation, PRC can cool an environment below ambient temperature without using external energy. In this study, three different windows in the wavelength range of 2.5–5 μm, 8–13 μm, and 16–27 μm were selected for maximized net cooling power. Hence, we designed a cylinder-centered honeycomb structure spectral selective emitter for adjustment of radiation properties. The impacts of geometrical parameters on absorbance/emissivity performance were analyzed. At the optimized geometer, 138.2 Wm-2 of net cooling power was achieved during the day when exposed to 994 Wm-2 of direct solar irradiation. On the other hand, since sunlight is blocked at night, a net cooling power of 198 Wm-2 was achieved. An equilibrium temperature of 264 K and 244 K were achieved at daytime and nighttime, respectively, by considering the ambient temperature of 300 K. Even parasitic convection and conduction are taken into account; the cooler achieved the performance to cool below the ambient temperature. Furthermore, the designed cooler was polarization-independent and exhibited good emissivity over a wide range of incidence angles from 0° to 75°.

Key words: Metamaterial, Radiative Cooling, Emissivity, Atmospheric Wind

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