Transparent fluoropolymer for daytime radiative cooling

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Radiative cooling (RC) is a passive way to dissipate heat to the universe through the atmospheric transparent window (ATW) with no electrical power. Thus, it has attracted attention to global energy saving such as cooling buildings, vehicles or solar cells. For the practical use of daytime RC, the RC materials must be weather-resistant, in addition to the strong absorption at the ATW (8 to 13 μm) and transparency at visible and near-infrared region. Here we report the RC efficiency of fluoropolymer (Lumiflon®, AGC) films and compared that of various samples: polydimethylsiloxane (PDMS) and polyethylene (PE) films, a silica plate, a silica plate with silica particles (ϕ20 μm), and a 100-nm thick gold film. The polymers were deposited on the gold film, which shows low RC efficiency, to reduce the RC from a substrate.

The RC efficiency of the materials was tested using liquid nitrogen (77K) in a glass Dewar vessel as a refringent, using an indoor setup illustrated in Fig. 1(a). The samples were set above the vessel with a distance of h = 160 mm. The thermocouples were placed at different positions, the back surface of the samples (P1) and in air close to the sample (P2). The difference of the temperatures at the sample (P1) and the air (P2), ΔT, was evaluated. The inner surfaces of the chamber was coated with aluminum foil to avoid the thermal emission from the chamber.

Figure 1(b) summarizes the RC performance, ΔT, as a function of the polymer thickness. The fluoropolymer films show great RC efficiency, even at the thickness less than 50 μm. The ΔT was 7.6 ± 0.5 K. As for PE films, ΔT gradually increases with the thickness and seems to be constant at ~ 300 μm and ΔT = 5.4 K. A 350 μm-thick PDMS film shows the RC efficiency of 7.7 K, as high as that of the fluoropolymer films. The silica plate with silica particles shows the RC performance higher than that of a silica plate. This is because of localized phonon-polaritions in the silica particles at around 9 μm. In conclusion, the fluoropolymer is a potential material for daytime RC, because of the following reasons: the fluoropolymer films have (a) high RC performance even with thicknesses less than 50 μm, (b) high weather-resistant property, and (c) 98% of transmission in the visible wavelength region.

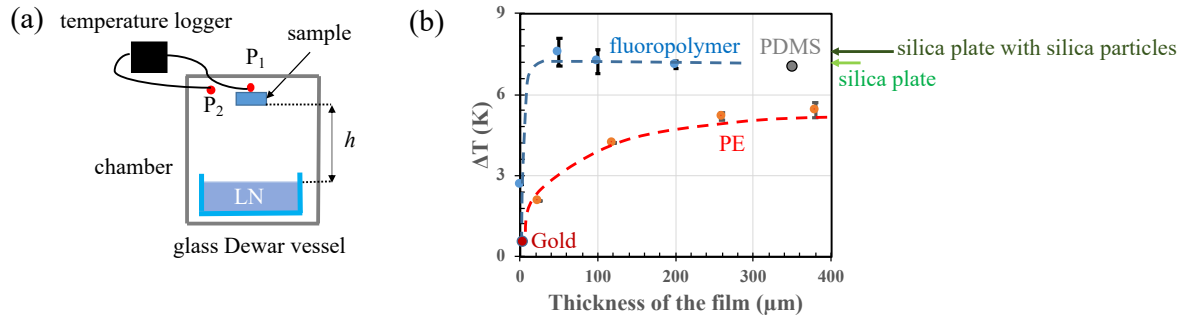

Fig. 1: (a) Setup for the RC measurements and (b) summery of the RC performace.