A single layer self-assembled radiative cooler

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Phonons, the quasi-particles that carry heat and sound, are practically involved in all kind of mechanical, optical, and thermal phenomena. By micro or nano-structuring a surface, phonons can be engineered to make them interact resonantly with photons and achieve interesting effects such as radiative cooling, which involves decreasing the temperature of a body without using electricity or any other kind of extra energy input. Radiative cooling has gained attention recently, because modern cooling technologies are particularly energy-consuming and a ten-fold grow in the energy demand associated to them is expected in the next 30 years, due to global warming. To address this global challenge, we propose a thermo-functional material that is capable of removing heat passively from devices or surfaces that undergo critical heating during operation. Our solution is based on a self-assembled single-layer array of SiO2 microspheres on a soda-lime slab. The working principle of the proposed cooling device is based on the interaction of the transverse optical phonons and equally polarized electromagnetic waves, which results in an intense evanescent field confined at the surface of a polar-dielectric interface. Such surface excitations, so called surface phonon polaritons (SPhP), have the ability to enhance thermal energy conduction [1], and, in the presence of a grating, they can be diffracted to the far-field as infrared thermal energy [2]. Thus, we engineer the thermo-optical properties of our device to remove heat and evacuate it through the transparent infrared atmospheric window, as infrared thermal energy to then deposit it into the outer space at 3K which acts as a heat sink. In this work, we will present how the temperature of a crystalline silicon wafer is lowered during daytime when the self-assembled single-layer cooler is placed on its surface, providing experimental evidence of above-ambient daytime radiative cooling.

References

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