Sunlight absorption with resonant silicon nanoparticles

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Efficient technologies to utilize solar energy are the keys for sustainable society. While photovoltaics has been the major method to make use of sunlight, sunlight-induced heat can be used for heaters and supplying hot water sum of which consume more than one half of the total energy consumption at home in Japan. To convert sunlight into heat, efficient absorption of sunlight is critically important. Here we demonstrate that resonant silicon nanoparticles dispersed in water are efficient sunlight absorbers to transduce sunlight to heat and vaporize water.

Figure 1(a) shows the scattering the absorption efficiencies of a 50-nm silicon nanoparticle. The resonance modes are well-known Mie resonances where the absorption profiles and electric filed amplitudes are shown in Figs. 1(b), 1(c) and Figs. 1(d) 1(e), respectively . It is important to note that at the resonances, both the scattering and absorption are enhanced. Since the resonance wavelengths can be tuned by changing the size of silicon nanoparticles, silicon nanoparticles with various particle sizes can cover the majority of solar spectrum.

In experiment, we dispersed the silicon nanoparticles in pure water to form silicon nanofluid and illuminated the silicon nanofluid by a solar simulator. Both the vaporization speed and temperature increase rate increased nearly twice compared to those of pure water. When we focused the sunlight from the solar simulator to have eight-fold irradiance compared to the standard irradiance, visible vapor was seen from the nanofluid. Our studies have shown the silicon nanoparticles are effective media for solar thermal applications such as heating or distilling water.

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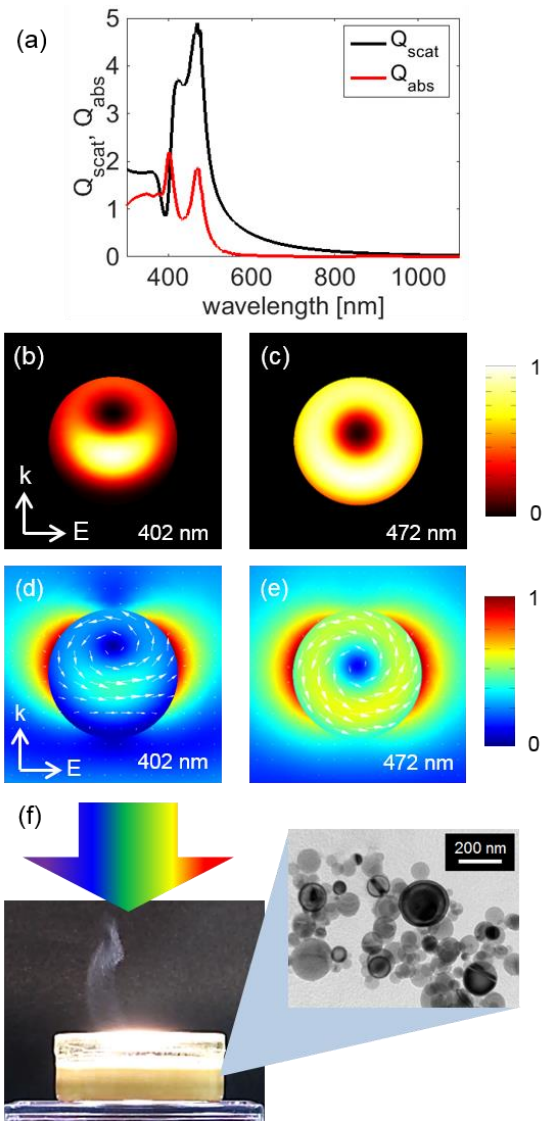

Fig. 1 (a) Absorption and scattering efficiencies of a 50-nm radius silicon sphere. (b,c) and (d,e) are the absorption mode profiles and electric field amplitudes at the resonances. (f) Photo of vapor generation from the silicon nanoparticles under sunlight. The inset shows the TEM image of the silicon nanoparticles.