Ultrathin Film Absorber for Solar Energy Conversion Systems

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Trade-off between the thickness and optical absorption of an active layer is critical for solar energy conversion systems. Thinner active layers are needed to reduce the cost of these systems or required due to poor carrier transport abilities. Kats et al. (*Nature Materials*, 2013, 12: 20-24) recently demonstrated a new type of absorber comprising an ultrathin absorbing dielectric layer coated on a metallic substrate with finite optical conductivity. The absorbing layer is only a few to tens nanometers in thickness which is much thinner than conventional optical coatings. However, this absorber shows narrowband absorption but broadband absorbers are much more useful. Here, we presented two strategies to achieve high broadband absorption in ultrathin films. First, the effective medium design strategy was used to achieve destructive interference over a broad spectrum to realize a solar thermal absorber. This strategy was experimentally and theoretically demonstrated with an absorber having 5 nm Ge, 10 nm Ti and 50 nm SiO_2 layers coated on an Ag substrate fabricated by a simple deposition method. The absorptivity of higher than 0.8 was achieved in the 15 nm thick Ge and Ti films from 400 to 950 nm. Secondly, destructive interference and surface plasmon resonance were combined to realize a solar water splitting absorber. This strategy was theoretically demonstrated with an absorber having 20 nm hematite planar film, a dielectric filled silver nanohole array and a silver substrate. This absorber has both high absorption comparable to nanophotonic structures due to supported destructive interference and surface plasmon resonance, and lower recombination loss characteristic of planar ultrathin films.