Amplification of Solar Energy Conversion and Desulfurization of Fuel at Hematite and Titania Photonic Crystals and Photonic Glass by Trapping Light

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Abstract

Significant gains in visible light absorbance and photocurrent generation were observed at frequencies to the blue of a photonic crystal stop band over a wide frequency range in quantum confined semiconductor films adsorbed on titania inverse opals. The observations raise several questions on the mechanism of light trapping in photonic crystals and disordered media, either absorbing or with absorbing matter localized therein. We propose to explore photonic effects at the blue and the red edges of the stop band on the photophysical processes and light energy conversion of absorbing matter localized in photonic crystals, and their dependence on, or tolerance to, disorder, to enhance the efficiency of third generation solar cells, solar-to-hydrogen conversion, and desulfurization of fuel. The effects of localizing a material in a nanoscale structure having a periodicity or pore size on the order of the wavelength of light will be investigated in different architectures designed as inverse opals, inverse opals with systematic variation of disorder, and photonic glass where Mie resonances are expected; and where the absorbing matter is either a quantum confined II-VI film at the interface, a molecular chromophore, or the material band itself. These findings will be applied to the design of optimum titania and hematite inverse opals or disordered inverse structures to amplify solar energy conversion in quantum dot solar cells, dye-sensitized solar cells, photoanodes for water oxidation, and the photocatalytic oxidative desulfurization of fuel by virtue of light trapping and other nanoscale effects facilitating charge separation.