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"Strategies for improving solar cell conversion efficiency-Light manipulation via down-shifting or plasmons"

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Αίθουσα σεμιναρίων στο ισόγειο του ΕΙΕ

Strategies for improving solar cell conversion efficiency- Light manipulation via down-shifting or plasmons.

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The last few years there has been a rapid renewable energy deployment in order to limit the effects of the greenhouse gas emissions produced by the use of fossil fuels which are responsible for air pollution and climate change. In this context there has been a tremendous effort to increase the conversion efficiency of solar cells without increasing their cost but on the contrary trying to even reduce their cost of production. Various methods have been proposed and tried towards this direction. The idea is to increase conversion efficiency beyond the Schockey-Queisser limit by eploying more efficiently the photons of the solar spectrum with energies much higher than the energy band gap of the absorber which otherwise would be lost through thermal relaxation of the related carriers before their collection by the electrodes. This can be done by manipulating suitably the solar light. Here we will present results from two different strategies. One of these is light manipulation via down-shifting. Down-shifting is the conversion of photons with energies much higher than the energy band gap of the absorber to photons of energy near the energy band gap of the absorber. These photons can be converted more efficiently as thermal relaxation is reduced. The other is light manipulation by enhancement of light intensity via light interaction with localized plasmons produced by silver nanoparticles.

As down-shifting material luminescent quantum dots with emission in suitable energies can be used. In this study we examined down-shifting provided by luminescent Cd-free $CuInS_2/ZnS$ quantum dots deposited on the active area of a silicon-based solar cell. $CuInS_2/ZnS$ quantum dots emitted at 1.8 eV and showed a broad photoluminescence (PL) spectrum. Thus we would expect efficient conversion of the higher energy photons to lower ones that could be absorbed and converted into electricity more efficiently from the silicon absorber underneath. In this study, we report on the increase of up to 37.5% in conversion efficiency of a silicon-based solar cell after the deposition of the dots. We showed that this effect was a combined effect of down-conversion and anti-reflection provided by the dots. We clearly distinguished the two effects and estimated that the enhancement due to the down-conversion was about 10.5%.

In another study, we investigated the enhancement of the light emitted by silicon nanocrystals embedded in a silicon dioxide matrix via localized plasmons emitted by silver nanoparticles which were located in close proximity to the light emitters. We showed a remarkable enhancement in the photoluminescence of the silicon nanocrystals by 20 times the intensity of the original photoluminescence intensity without the silver nanoparticles, which was attributed mainly to the enhancement of the emission rate of the silicon nanocrystals due to the electric field enhancement provided by the excited surface plasmons of the neighboring silver nanoparticles.

The demonstration of these two strategies of light management can be proved very useful for the enhancement of the conversion efficiency of conventional solar cells.

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