PhD Open Days

Nanostructured Sol-Gel coatings for solar energy applications

PHD PROGRAMME ChemMat (PD/PB/135580/2018) - Departamento de Química

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Spectral conversion

A solution to overcome the **Shockley – Queisser limit**, that states that a single pn junction can have an efficiency limit about 30% is the **spectral conversion**, which modifies the incident solar spectrum so that a better match is obtained. With spectral conversion, rather than modifying the materials to fit the spectrum, it is possible to modify the spectrum to suit the material.

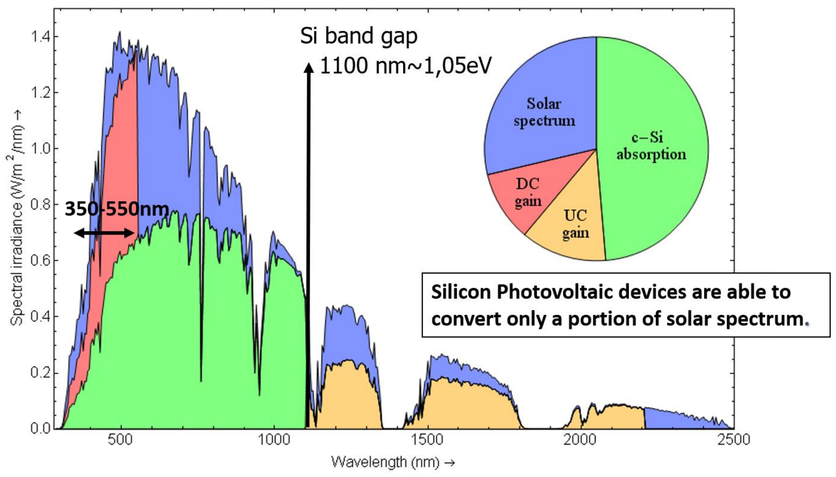


Figure 1 Solar spectrum - gain from spectral conversion in each range of wavelength.

By exploiting optical processes such as **upconversion**, downconversion and downshifting that occur in various materials, like **Lanthanides**, and **adapting it to the existing Silicon solar cells, such as by the deposition of thin films**, it is possible to exceed the Shockley – Queisser limit and increase the efficiency converting the photons with lower or higher energy than the bandgap of the material of the solar cell.

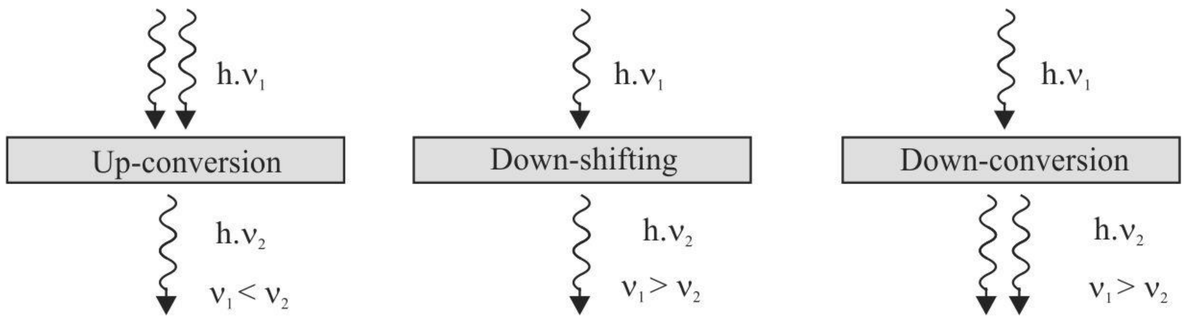
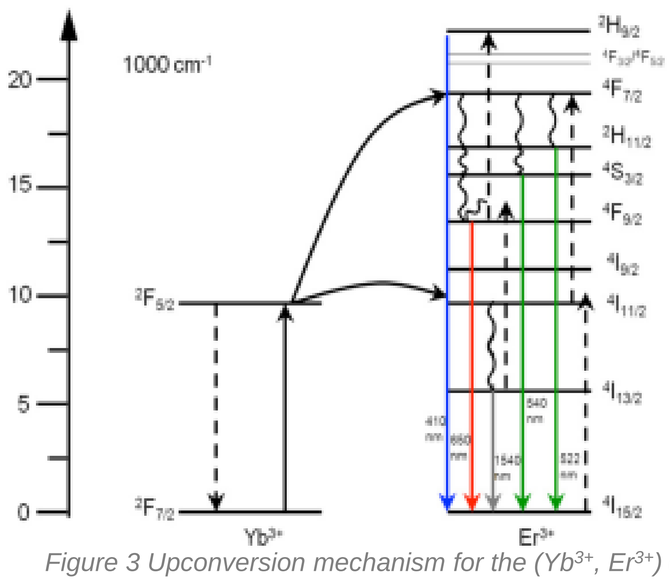


Figure 2 Concepts of spectral conversion, from the left to the right: upconversion, downshifting and downconversion.

Downshifting and downconversion are utilized to reduce losses through thermalization.

Upconversion increases the overall efficiency by dealing with the transmission losses by upconverting IR photons into photons of higher energy.

Upconversion in the (Yb^{3+}, Er^{3+}) couple



The main route is a two-step energy transfer after excitation around 980 nm in the Yb^{3+} ion that leads to excitation to the $^4F_{7/2}$ state of the Er^{3+} ion. After relaxation from this state, emission is observed from the $^2H_{11/2}$ level, the $^4S_{3/2}$ level (green), and the $^4F_{9/2}$ level (red) .

Figure 3 Upconversion mechanism for the (Yb^{3+}, Er^{3+}) couple.

Sol-gel synthesis

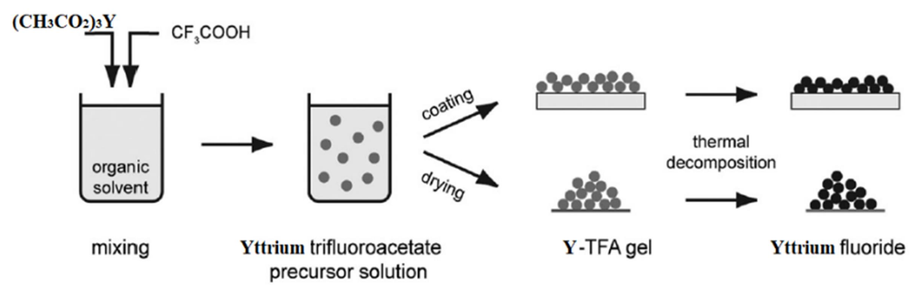


Figure 4 Thin film and xerogel Yttrium fluoride preparation via sol–gel, followed by thermal decomposition.

Low-cost liquid deposition process for optical films at room temperature, which can be subsequently densified through heat treatment at moderate temperatures. It is ideal for depositing films on a variety of substrates such as glass, metal, and plastic, including multilayer films with complex structures.

Upconversion measurements on Yb^{3+}, Er^{3+} codoped YF_3

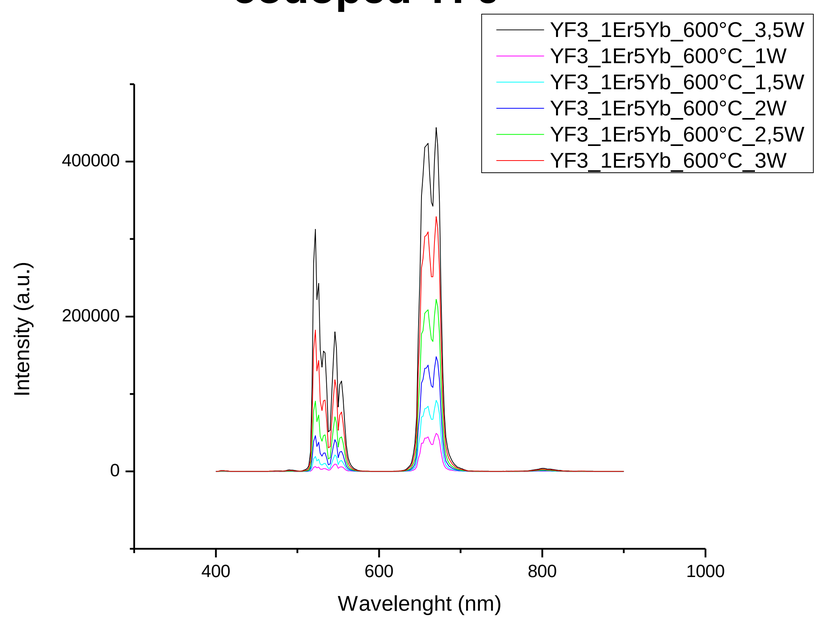


Figure 5 Power dependence of Upconversion intensity – exc. 980 nm. The intensity increase, increasing the pump power.

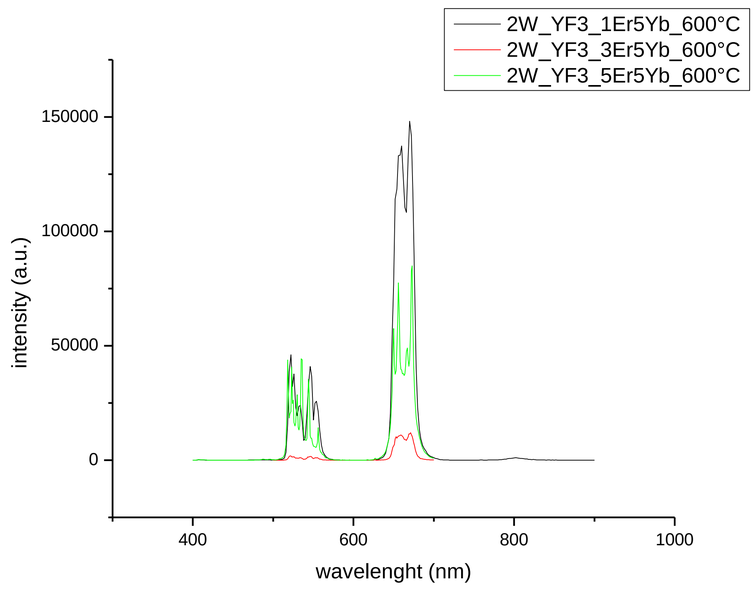


Figure 6 Dependence on the dopants concentration of Upconversion intensity – exc. 980 nm. Manteining a lower concentration of Er it's possible to observe an increasing in the intensity.

Acknowledgments

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