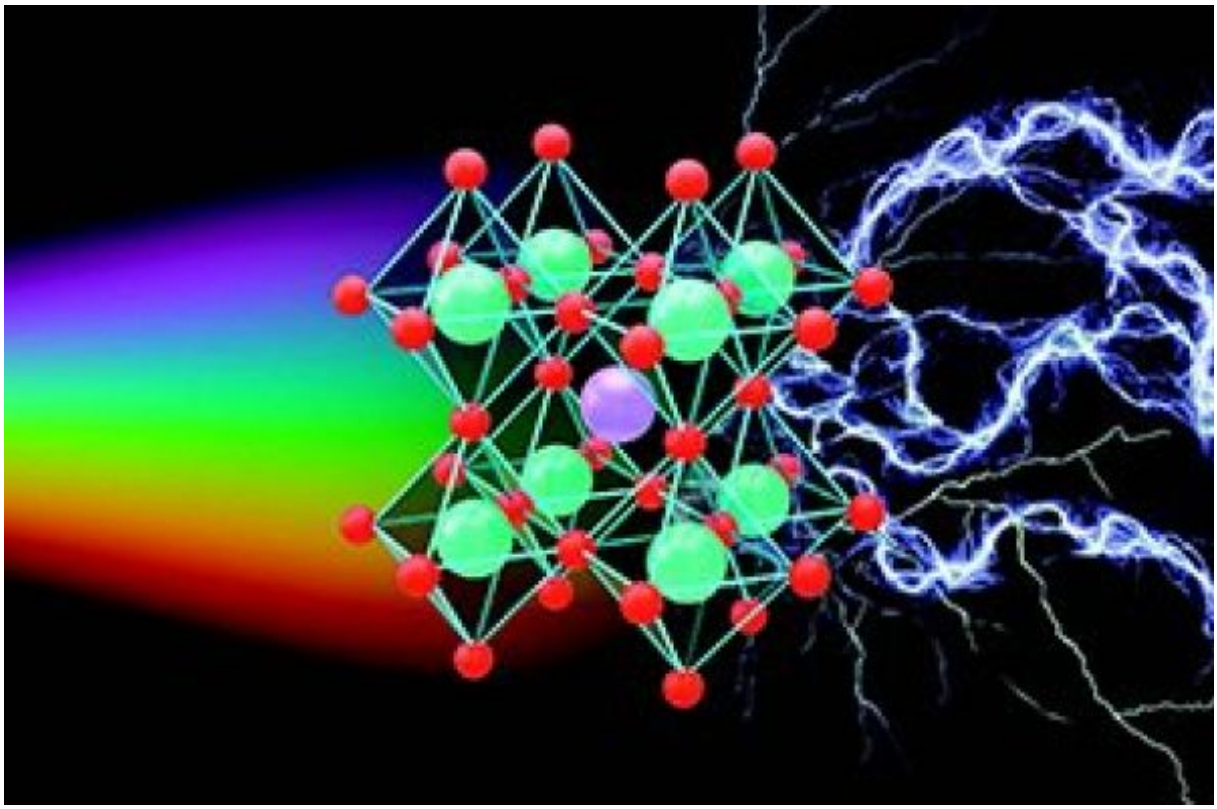

PhD Thesis Defense GUILLERMO MARTINEZ-DENEGRI SANCHEZ 'Light Harvesting and Energy Efficiency in Perovskite Solar Cells and Their Applications'

GUILLERMO MARTINEZ-DENEGRI SANCHEZ

September 29, 2021

11:00

ICFO Auditorium and Online (Teams)

Wednesday, September 29, 2021, 11:00. ICFO Auditorium and Online (Teams)

GUILLERMO MARTINEZ-DENEGRI SANCHEZ

Organic Nanostructured Photovoltaics

ICFO-The Institute of Photonic Sciences

The environmental issues associated with the use of conventional fuels necessitates the utilisation of renewable energy sources, as well as the implementation of energy efficient designs, in order to decrease electricity consumption. Photovoltaic (PV) technology can be

employed for both approaches by converting not only natural but, also, artificial light into electricity. Among the different emerging PVs, perovskites achieve the highest power conversion efficiency, providing a widely tuneable bandgap with minimum open circuit losses. Moreover, their fabrication uses readily available materials, and does not necessarily require either the use of high temperature processes or vacuum deposition techniques. In this thesis, we enhance light harvesting in perovskite solar cells, and approach the energy efficiency concept through their optimised fabrication and integration in light selective structures. This is accomplished by the implementation of optical and material strategies applied to specific perovskite solar cell designs. The results prove that such strategies provide enhanced light absorption and optimal PV performance in low temperature devices, and enable the recycling of light into electricity for alternative photonic applications. The approaches presented could be utilised in future procedures to decrease the amount of Pb employed in perovskite solar cells, and to reduce the energy consumption during fabrication and the operation of other optoelectronic devices.

The thesis is organised into four chapters. Chapter 1 serves as an introduction, where the current energy situation and PV technology are analysed, together with an insight into light harvesting and energy efficiency in perovskite solar cells. In Chapter 2, we demonstrate the employment of a periodic structure to propagate ergodic light in order to increase light absorption in perovskite solar cells, as would happen by employing randomly textured surfaces. This structure serves as a tool to decrease the Pb content used in perovskite solar cells, since 30% less material can be used to obtain a solar cell with equal performance. Then, in Chapter 3, the same periodic configuration with a thin film structure deposited on its surface is applied as a waveguide, which is also able to transmit polarised light. Moreover, two perovskite solar cells integrated on the sides recycle the non-transmitted light into electricity, increasing the energy efficiency of the optical process, with further application in liquid crystal displays (LCDs). Finally, in Chapter 4, we demonstrate the suitable application of a nanoparticle bilayer made of one layer of SnO_2 and another of TiO_2 as n-type materials in perovskite solar cells. These types of devices, based on low temperature processes, are proven to perform better than those containing one type of nanoparticles, especially in semi-transparent devices. In such devices we achieved an enhancement in performance of up to 30% for solar cells based on extremely thin active layers.

Wednesday, September 29, 2021, 11:00. ICFO Auditorium and Online (Teams)

Thesis Director: Prof Dr. Jordi Martorell Pena

Guillermo Martinez-Denegri Sanchez's Thesi Cover