ICFO

Felicitats a la nova graduada de doctorat de l'ICFO

La Dra. Catarina Ferreira s'ha graduat amb una tesi titulada ?Ligh absorption and ergodicity in systems that transform light int other forms of energy'

September 27, 2023

Felicitem la Dra. Catarina Ferreira que avui ha defensat la seva tesi a la sala Elements Roo de l'ICFO
La Dra. Ferreira va obtenir el seu master Fisica Aplicada a la Universidade do Minho Portugal. Es va unir a l'ICFO com a estudiant de doctorat al grup de recerca de Organi Nanostructured Photovoltaics dirigit pel professor Dr. Jordi Martorell. La tesi de la Dra Ferreira titulada ?Light absorption and ergodicity in systems that transform light into othe forms of energy' ha estat supervisada pel professor Dr. Jordi Martorell

RESUMEN

To mitigate the present environmental crisis, caused by the excessive use of fossil fuels and associated release of carbon dioxide into the atmosphere, it is necessary to significantly reduce worldwide energy consumption, to rely more strongly on clean and renewable sources of energy, but also to maximize energy efficiency in currently existent technologies that make use of energy. To reach such maximal energy efficiency, it is necessary to optimize light propagation, harvesting, and utilization in the different existent optoelectronic technologies. Given that a considerable portion of the global energy consumption is dedicated to illumination or devices incorporating illumination sources in them, a clear path to maximize energy-efficiency would imply minimizing the light losses in such kind of systems. In addition, for maximal energy conversion efficiency it is essential to optimize light absorption in systems that perform an unassisted sunlight transformation into other forms of energy, such as electrical or chemical.

To reach the double goal of optimizing light utilization and transformation, in this thesis we consider the study of optical ergodic configurations, where light rays are randomized after a few bounces at the interfaces, losing any correlation with the external incident state and giving rise to an isotropic radiation inside the material. In Chapter 2 of the thesis, we demonstrate that an ergodic geometry can be used to obtain homogeneously distributed polarized light emission. In the same ergodic system, we also demonstrate that the light with the unwanted polarization can be trapped and transformed back into electricity by using a couple of perovskite solar cells. Such features are potentially useful to increase energy efficiency in optoelectronic devices incorporating illumination sources in them, as is the case of liquid crystal displays. A similar ergodic light propagation is also considered in Chapter 3 to determine what the maximal light trapping and effective light absorption is in a $BiVO_4$-based photoanode of a photoelectrochemical cell used for light transformation into hydrogen. The limits in the efficiency of such energy transformation are seen to be strongly linked to the weakly light-absorbing sub-bandgap states. A three-dimensional nano-structuration of the photoanode in the photoelectrochemical cell is explored as a path to eventually reach ergodicity for light propagation in the photoanode. In the final chapter of the thesis, we consider a tandem construction of two complementary light absorption elements, such as a $BiVO_4$ photoanode and an organic solar cell, to obtain an unassisted conversion of sunlight into hydrogen in photoelectrochemical cells. Optical multilayers designed by implementing an inverse problem-solving approach are found to be an essential ingredient to properly balance light absorption among such two light-absorbing elements in the tandem, leading to an optimal solar-to-hydrogen conversion.

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