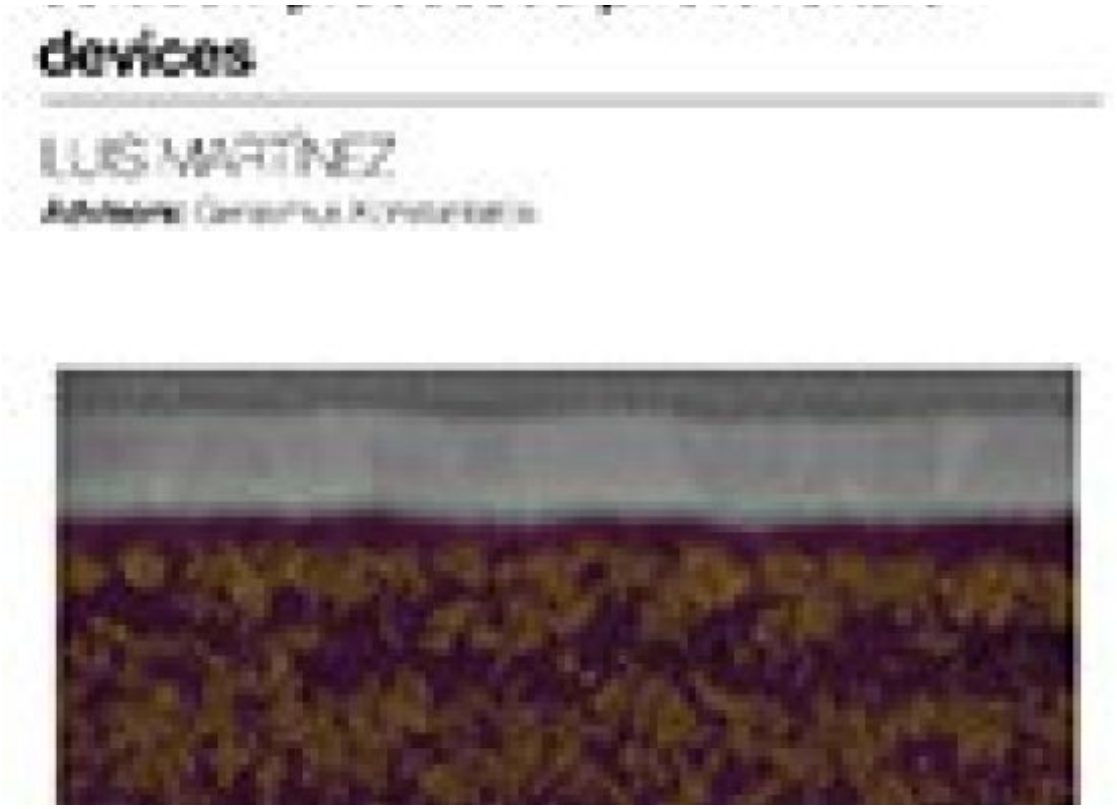


# PhD Thesis Defense LUIS MARTINEZ 'N-Type Bismuth Sulfide Coloidal Nanocrystals and their Application to Solution-Processed Photovoltaic Devices'

LUIS MARTINEZ

October 31, 2014

Friday October 31, 10:00. ICFO Auditorium

**LUIS MARTINEZ**

Solution-processed nanophotonic devices

ICFO-The Institute of Photonic Sciences

Photovoltaics has become a technology of increasing importance during the last decades as a platform to satisfy the energy needs of today without compromising future generations. Traditional silicon-based solar cells suffer from high material and fabrication costs.

Alternative technologies such as organic photovoltaics offer promising low-cost material and processing advantages, however at the cost of chemical instability. Inorganic colloidal nanocrystals have attracted significant attention, due to the unique combination of chemical robustness, panchromatic solar harnessing and low-cost solution processability. However, the state-of-the-art nanocrystalline semiconductors raise some concerns regarding their suitability for industrial applications due to the presence of highly toxic heavy metals (such as lead or cadmium). Moreover, most of these materials are p-type, and are usually employed together with large bandgap n-type semiconductors that do not contribute to photocurrent generation. The field on non-toxic, electron-acceptor nanocrystalline semiconductors with appropriate energy levels, high optical absorption and bandgap suited to optimal solar harnessing still remains unexplored. The aim of this thesis is to investigate the potential of bismuth sulfide nanocrystals to be employed as environmental-friendly n-type nanomaterials for efficient solar harnessing.

Chapter 2 presents an in-depth physicochemical and optoelectronic characterization of bismuth sulfide colloidal nanocrystals. Bismuth sulfide nanocrystals are n-type semiconductors and have the appropriate bandgap and energy levels for efficient solar harnessing. Therefore, bismuth sulfide nanocrystals have the potential to be employed as the electron accepting material in heterojunction-based solar cells with most high-performing materials investigated for third-generation photovoltaics.

Bismuth sulfide nanocrystals are employed in Chapter 3 as electron accepting materials in hybrid organic-inorganic solar cells. Typical electron accepting materials and semiconducting polymers used in organic photovoltaics do not harness infrared radiation, thus limiting their solar harnessing potential. Bismuth sulfide nanocrystals can be used as electron accepting materials in hybrid organic-inorganic solar cells and extend the sensitivity range of P3HT-based solar cells into near-infrared wavelengths.

Chapter 4 investigates the nanomorphology and photovoltaic performance of hybrid solar cells based on bismuth sulfide nanocrystals and thiol-functionalized semiconducting polymers. This novel class of functionalized polymers binds to the surface of bismuth sulfide nanocrystals, thus preventing nanocrystal agglomeration, shows deeper ionization potential levels and exhibits improved electronic interaction within the organic-inorganic

nanocomposite.

In Chapter 5, bismuth sulfide nanocrystals are employed together with lead sulfide quantum dots in p-n junction-based all-inorganic solution-processed photovoltaic devices. This system opens the possibility of fabricating all-inorganic solution-processed bulk heterojunctions, a device architecture where requirements on carrier lifetime are eased. This way, a broader range of inorganic nanocrystalline materials can be explored in the quest for novel non-toxic third-generation photovoltaics

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**Thesis Advisor: Prof. Gerasimos Konstantatos**