

# 화학과 대학원 세미나

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## Infrared Colloidal Quantum Optoelectronics: LEDs and Lasers

Gerasimos Konstantatos

ICFO-Institut de Ciències Fotoniques, The Barcelona Institute of Science and Technology,  
Castelldefels, Spain

Solution Processed CMOS compatible Infrared Optoelectronics is a key enabling technology to revolutionize consumer electronic markets offering unprecedented opportunities for low-cost food quality inspection, environmental monitoring, 3D imaging, automotive safety and night vision applications just to name a few. Recent progress in CMOS compatible CQD photodetectors have addressed the InGaAs image sensor challenge and the next step would be the development of the correspondingly low-cost tunable light sources. In this talk, I will be presenting recent results from my lab at ICFO on highly performant infrared CQD LEDs and downconverting light emitters.

I will present our device architecture approach that allowed us to achieve very high PLQY in conductive solid state QD films that when implemented in a LED stack led to 8% EQE [1]. I will then discuss the optimization of the matrix supply dots that improved charge balance and allowed to reach 8% EQE at high radiance along with a stark improvement in operational stability [2]. I will then elaborate on fine-tuning the energetic potential landscape in the matrix which taken together with optimized optical out-coupling schemes reached a QE of 18% at 1550 nm. The possibility to tune the light spectrum of such QD films by stacking layers of QDs with different bandgaps offers exquisite control over the emission spectrum offering the opportunity to develop solid-state thin film broadband emitters in the SWIR, either optically or electrically excited with implications in SWIR spectroscopy [3].

The second part of my talk will discuss recent progress on infrared CQD lasers comprising doped PbS CQDs integrated in a DFB cavity [4]. Besides this I will present our approach of elongating Auger lifetime by engineering QD solids at the supra-nanocrystalline level offering lasers with improved optical linewidths, reduced thresholds and drastically improved stability [5]. The last part of my talk, if time allows, will be devoted to a different line of research on how to tune the optical properties of nanocrystals by engineering their atomic configuration. I will show an example of AgBiS<sub>2</sub> NCs whereby cation disorder has been homogenized yielding a material with very high optical absorption coefficient. This material has further been optimized in a solar

cell stack leading to a record high PCE of 9% for an extremely thin absorber cell of only 35 nm. [6]

## References

- [1] [High-efficiency colloidal quantum dot infrared light-emitting diodes via engineering at the supra-nanocrystalline level](#), *Nature Nanotechnology* 14 (1), 72-79, 2019
- [2] [Highly Efficient, Bright, and Stable Colloidal Quantum Dot Short-Wave Infrared Light-Emitting Diodes](#), *Advanced Functional Materials* 30 (39), 2004445, 2020
- [3] [Solid-State Thin-Film Broadband Short-Wave Infrared Light Emitters](#), *Advanced Materials* 32 (45), 2003830, 2020
- [4] [Solution-processed PbS quantum dot infrared laser with room-temperature tunable emission in the optical telecommunications window](#), *Nature Photonics* 15 (10), 738-742, 2021
- [5] [Low-Threshold, Highly Stable Colloidal Quantum Dot Short-Wave Infrared Laser enabled by Suppression of Trap-Assisted Auger Recombination](#), *Advanced Materials* 34 (3), 2107532, 2022
- [6] Cation disorder engineering yields AgBiS<sub>2</sub> nanocrystals with enhanced optical absorption for efficient ultrathin solar cells. *Nature Photonics* 2022 <https://doi.org/10.1038/s41566-021-00950-4>

## Biosketch

**Gerasimos Konstantatos**, received his PhD in the department of Electrical and Computer Engineering from the University of Toronto, ON, Canada in 2008. In 2009 he joined ICFO as an assistant Professor and since 2015 he is an ICREA research Professor at ICFO leading the Functional Optoelectronic Nanomaterials Group. His interests lie in developing solution processed nanomaterials, quantum dots and 2D materials for optoelectronic and solar cell applications. He is the recipient of MIT TR35 Spain award in 2012 and Fresnel Prize in 2013 for his salient contributions in the field of colloidal quantum dot optoelectronics. He has been awarded twice with ERC Consolidator Grants for the development of non-toxic solar cells and CQD Intraband optoelectronics.