

Infrared heavy-metal-free quantum dots deliver sensitive and fast sensors for eye-safe LIDAR applications

ICFO researchers unveil a new strategy that significantly enhances the performance of silver telluride colloidal quantum dots for shortwave infrared (SWIR) photodetection, paving the way for the widespread adoption of SWIR detectors in consumer electronics and automotive applications.

April 01, 2025

The frequency regime lying in the shortwave infrared (SWIR) has very unique properties that make it ideal for several applications, such as being less affected by atmospheric scattering as well as being i¿½eye-safei¿½. These include Light Detection and Ranging (LIDAR) - a method for determining ranges and distances using lasers -, space localization and mapp ng, adverse weather imaging for surveillance and automotive safety, environmental monitor ng, and many oth rs. However, SWIR light is currently confined to niche areas, like scientific instrumentation

and military use, mainly because SWIR photodetectors rely on expensive and difficult-to-manufacture materials. In the past few years, colloidal quantum dots - solution-processed semiconducting nanocrystals - have emerged as an alternative for mainstream consumer electronics. While toxic heavy-metals (like lead or mercury) have typically been used, quantum dots can also be made with environmentally friendly materials such as silver telluride (Ag2Te). In fact, silver telluride colloidal quantum dots show device performance comparable to their toxic counterparts. But they are still in their infancy, and several challenges must be addressed before they can be used in practical applications. Now, ICFO researchers **Dr. Yongjie Wang**, **Hao Wu**, **Dr. Carmelita Roda**, **Dr. Lucheng Peng**, **Dr. Nima Taghipour**, and **Miguel Dosil**, led by **ICREA Prof. Gerasimos Konstantatos**, have demonstrated a new method to create silver telluride colloidal quantum dots that addressed these challenges. The team also developed the **first proof-of-concept SWIR LIDAR using colloidal quantum dots made of non-toxic materials**, successfully measuring distances over 10 meters with decimetre resolution. The study, published in Advanced Materials, marks a key step toward practical, cost-effective, and environmentally-friendly LIDAR systems for consumer and automotive markets.

Overcoming challenges in non-toxic colloidal quantum dots for SWIR photodetection

Silver telluride colloidal quantum dots have traditionally faced three challenges: high dark current, limited linear dynamic range and response speed.

Dark current is the small electrical current that flows through a photodetector even when no light is present. High dark current increases noise, limiting sensitivity to weak signals. For LIDAR applications, this ultimately limits the ability to detect distant objects, as greater distances or atmospheric interference lead to more signal attenuation. The linear dynamic range refers to the range between the minimum and maximum detectable light intensity. The wider the range, the higher is the contrast of the scene the SWIR detector can sense and visualize. Finally, the response speed of a photodetector measures how quickly it can react to changes in incident light intensity. A fast response facilitates accurate distance measurement and optical telecom, among others.

ICFO researchers improved drastically all three features compared to the previous record, which was reported by themselves in Nature Photonics just one year ago. Specifically, they achieved a dark current density of less than 500nA/cm2, an external quantum efficiency at 1400 nanometres of 30%, an LDR in excess of 150dB and a time response as fast as 25 nanoseconds. These successful results encouraged them to build a proof-of-concept SWIR LIDAR, using, for the first time, colloidal quantum dots made of materials compliant with the Restriction of Hazardous Substances directive. **The device measured distances over 10 meters with decimetre resolution, showcasing a promising potential of silver telluride colloidal quantum dots for LIDAR applications.**

i¿½At the beginning of the project, we didn't expect such a significant leap in the final devi

e performancei¿½, recalls Dr. Yongjie Wang, first co-author of the paper. The team starte by optimizing the synthesis of quantum dots to eliminate surface defects, which tend to re uce efficiency. However, this strategy alone was not enough. i¿½Initially, the device perfo mance was not very satisfactory. It wasn't until we applied a silver nitrate post-treatment o our quantum dot thin film that we saw major improvements, suggesting that this optimi ation approach was promisingi¿½, adds the res
archer. The proposed engineering strategy advances the development of SWIR optoel ctronic devices by leveraging the cost-effectiveness and manufacturing advantages of c lloidal quantum dots, while considerably enhancing their performance as an environ entally friendly alternative. Future research will focus on achieving even faster respons times, higher quantum efficiency and more reliable operation under realistic tempera ure and humidity conditions. These advancements, including the present study, will bring us ne step closer to the ultimate goal: a widespread adoption of SWIR light in consumer elec

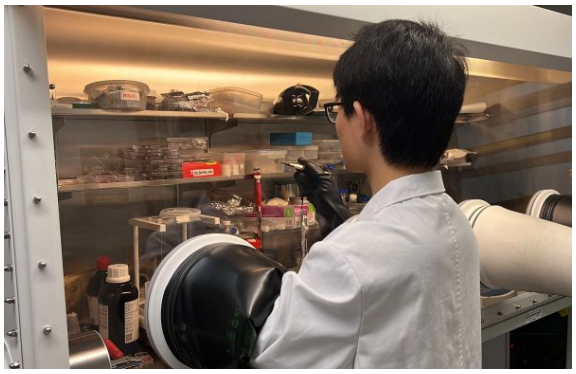
Reference:

Wang, H. Wu, C. Roda, L. Peng, N. Taghipour, M. Dosil, G. Konstantatos, Shortwave Infrared Light Detection and Ranging Using Silver Telluride Quantum Dots. Adv. Mater. 2025, 2500977.

DOI: https://doi.org/10.1002/adma.202500977

Acknowledgements:

G.K. acknowledges financial support from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement no. 101002306), the Fundacio Privada Cellex, the program CERCA and ?Severo Ochoa' Centre of Excellence CEX2019-000910-S funded by the Spanish State Research Agency. This project has also received funding from the European Union under grant agreement No 101119489. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. C.R. acknowledges MCIU (Ministerio de Ciencia Innovacion y Universidades)/AEI(Agencia Estatal de Investigacion)/10.13039/501100011033 and European Union i¿½NextGenerationEUi¿½/PRTR under the Juan de La Cierva fellow hip JDC2022-049722-I.



Hao Wu working in the lab at ICFO. Credit: Jordi Cortes, ICFO.