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Scientists Develop Cost-Effective Lasers for Extended SWIR Applications

A ground-breaking study published in Advanced Materials showcases a significant advancement in laser technology, promising more affordable and scalable solutions for applications ranging from environmental monitoring to biomedical imaging. Researchers have developed the first colloidal quantum dot (CQD)-based laser capable of operating across the entire extended short-wave infrared (SWIR) spectrum.

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Current laser technologies for the extended SWIR spectral range rely on expensive and complex materials, limiting their scalability and affordability. To address these challenges, ICFO researchers **Dr. Guy L. Withworth**, **Dr. Carmelita Roda**, **Dr. Mariona Dalmases**, **Dr. Nima Taghipour**, **Miguel Dosil**, **Dr. Katerina Nikolaidou**, **Hamed Dehghanpour**, led by **ICREA Prof. Gerasimos Konstantatos**, have presented a novel approach based on colloidal quantum dots in an Advanced Materials article. The team managed to **emit coherent light** (a necessary condition to create lasers) **in the extended SWIR range with large colloidal quantum dots** made of lead sulfide (PbS).

This new CQD-based technology offers a solution to the aforementioned challenges while maintaining compatibility with silicon CMOS platforms (the technology used for constructing integrated circuit chips) for on-chip integration.

Their PbS colloidal quantum dots are the first semiconductor lasing material to cover such a broad wavelength range. Remarkably, the researchers accomplished this without altering the dots' chemical composition. **These results pave the way towards the realization of more practical and compact colloidal quantum dots lasers. Further to that, the team demonstrated lasing - for the first time in PbS quantum dots- with nanosecond excitation,** replacing the need for bulky and costly femtosecond laser amplifiers. That was achieved by employing larger quantum dots, increasing thus the absorption cross-section of the dots tenfold, leading to a dramatic reduction in the optical gain threshold -the point at which the laser light emission becomes an efficient process.

The ability to produce low-cost, scalable infrared lasers in the extended SWIR range addresses critical bottlenecks in various technologies. This innovation has transformative potential for diverse applications, including hazardous gas detection, eye-safe LIDAR

systems, advanced photonic integrated circuits, and imaging within the SWIR biological window. Industries relying on LIDAR systems, gas sensing, and biomedicine could greatly benefit from this cost-effective and integrable solution. Moreover, this breakthrough supports the transition to silicon-compatible photonic integrated circuits, enabling greater miniaturization and widespread adoption.

"Our work represents a paradigm shift in infrared laser technology," said ICREA Prof. Gerasimos Konstantatos. "For the first time, we've achieved lasing in the extended SWIR range with solution-processed materials at room temperature, paving the way for practical applications and the development of more accessible technologies."

Reference:

L. Whitworth, C. Roda, M. Dalmases, N. Taghipour, M. Dosil, K. Nikolaidou, H. Dehghanpour, G. Konstantatos, Extended Short-Wave Infrared Colloidal Quantum Dot Lasers with Nanosecond Excitation. Adv. Mater. 2024, 2410207.
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ICFO researcher Dr. Carmelita Roda working on the experiment. Credit: ICFO.