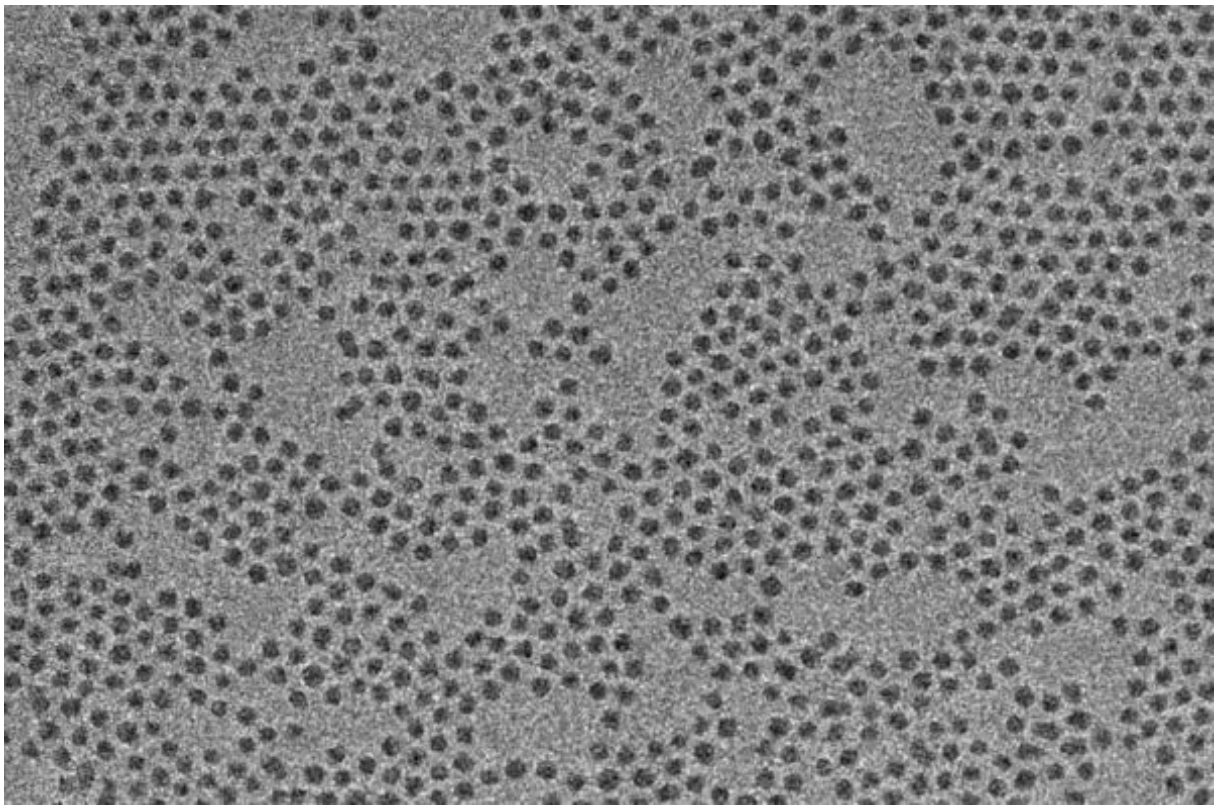


New InSb quantum dot synthesis to detect infrared light

A new synthesis method developed at ICFO and published in Nature Communications produces large, homogeneous quantu dots capable of absorbing short-wave infrared (SWIR) light. Usin them, researchers have built SWIR photodetectors, which hav applications in optoelectronics, including autonomous vehicle and fire prevention.

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Quantum dots, tiny semiconductors that behave like a single atom, can absorb and emit light at different wavelengths depending on their size (the larger the dots, the longer the wavelength). In particular, quantum dots made of indium antimonide (InSb) exhibit multiple advantages. They are environmentally friendly, comply with hazardous substance restrictions (RoHS regulations), and can be integrated with CMOS technology (the main technology used for constructing integrated circuit chips). More importantly, they can access the short-wave infrared (SWIR) regime, which can be used to image through smoke and fog as well as at night and from a remote location, all while keeping the eyes safe.

But to enable high-quality InSb quantum dots suitable for advanced optoelectronic applications, it is crucial to understand the mechanisms that govern their formation and growth. Now, ICFO researchers, **Dr. Lucheng Peng**, **Miguel Dosil**, **Dr. Debranjan Mandal**, **Hao Wu** and **Aditya Malla,** led by **ICREA Prof. Gerasimos Kontantatos,** have developed a synthesis method called **monomer-concentration-controlled approach** (MCCA) that yields InSb quantum dots that are large enough to absorb SWIR light. The technique, recently published in Nature Communications, **produces a homogeneous size distribution, allowing the quantum dots to absorb a very precise wavelength within the SWIR range** (950 to 1900 nm). Based on this approach, the researchers also built SWIR photodetectors whose external quantum efficiency exceeds that of all previous devices based on heavy metal-free quantum dots.
Previous methods such as the continuous-injection approach, in contrast, produce quantum dots that, in general, are too small, or when they grow larger, they suffer from very large size distribution. The reason, the ICFO team has shown, is the constant injection of chemical precursors, which react to form InSb molecules (monomers). The continuous injection was traditionally believed to be essential, because a high concentration of molecules is needed for them to bind together and form small nuclei -the seeds that then grow into quantum dots. "This is useful at the beginning, to obtain a large number of seeds. But at some point, you do not want more nuclei; you want the existing ones to grow larger," explains Dr. Lucheng Peng, first author of the article. Continuous injection, however, saturates the medium with InSb molecules, which then tend to cluster together forming new nuclei rather than attach to existing ones.
The conceptual change proposed by ICFO is quite simple: **replace continuous injection with a two-step injection process**. In the first phase (nucleation phase), which lasts only 30 seconds, the precursors are continuously introduced in large quantities, just as in the previous method. Then the injection rate is drastically lowered, slowing down the concentration of new molecules so that they prefer to attach to the already-formed nuclei (growth phase).
As a result, **quantum dots become large and uniformly distributed in size**. These high-quality InSb quantum dots were then encapsulated in a layer of indium phosphide, enhancing the device's stability and performance and leading to SWIR photodetectors (up to 1.7 m) wit high external quantum efficiencies. According to Prof. Gerasimos Konstantatos, lea researcher of the study: i¿½This finding not only offers a material platform suitable or investigating deeper the photo-physics of this class of quantum dots, but also unleas es many applications for SWIR optoelectronics, such as **photodetectors, LEDs and even lasers** .i¿

Reference:

Peng, L., Dosil, M., Mandal, D. et al. Synthesis of monodisperse InSb colloidal quantum dot by monomer concentration control for short-wave infrared photodetectors.Nat Commun **17**,

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