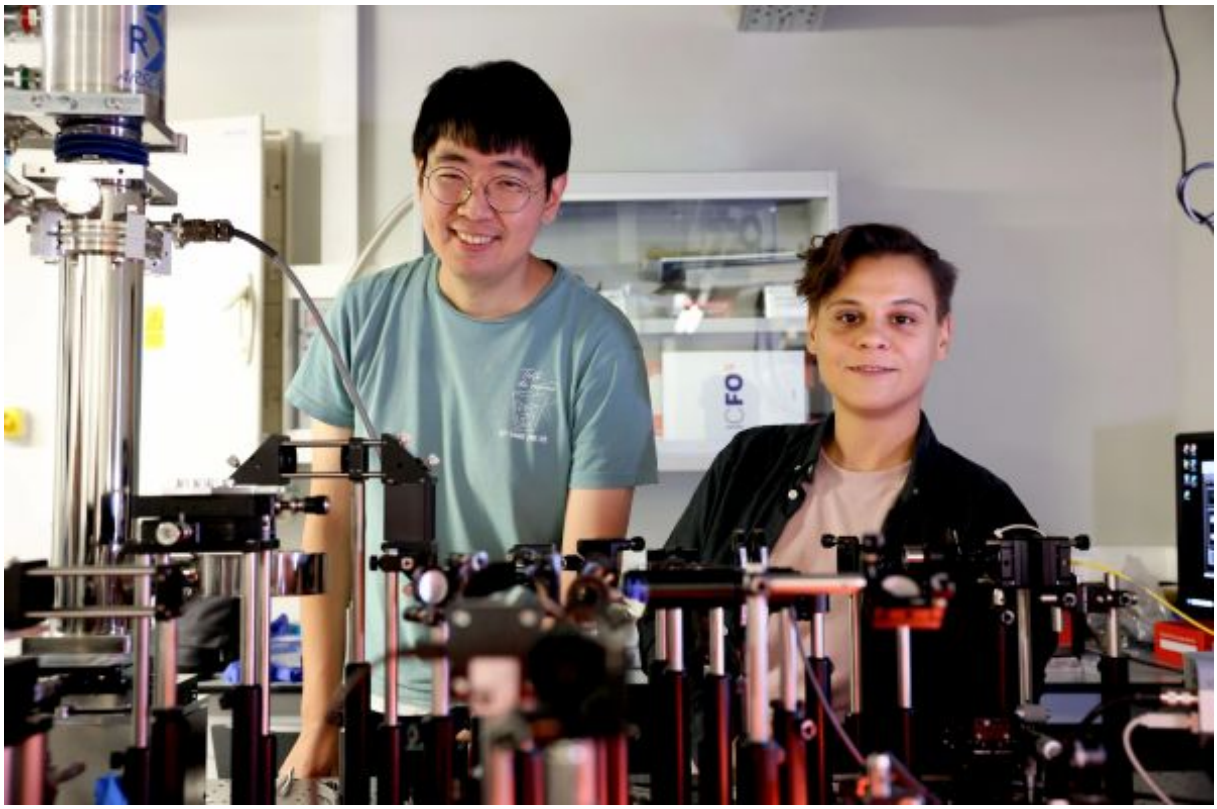


Controlling shell growth on quantum dots yields more efficient SWIR LEDs

ICFO researchers have achieved a record light-emission efficiency for SWIR quantum dots by understanding and controlling how a shell grows around the dot's core. In a study published in Nature Communications, they have used these dots to build LEDs, which set a new state of the art for heavy-metal-free SWIR devices.

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Short-wave infrared (SWIR) light-emitting diodes (LEDs), which emit at wavelengths of roughly 1,000-2,500 nm, could unlock applications that are beyond the reach of conventional visible or near-infrared LEDs, including machine vision, biological imaging and optical communication. Indium Arsenide (InAs) quantum dots have recently emerged as promising SWIR light sources, mainly because they are free of heavy metals, which makes them environmentally friendly, and solution-processable, which simplifies device fabrication. Nevertheless, the light emission of quantum dots can become weak, mainly because their surface is prone to defects. Another material is thus grown around the core as a shell. This, however, introduces another challenge: because the core and the shell are typically made of

different materials, whose atoms are not equally spaced, strain builds up at the interface. Eventually, this also gives rise to defects that reduce the photoluminescence quantum yield (PLQY), a measure of how efficiently a material emits light.

Scientists are seeking ways to increment this factor as much as possible, and ICFO researchers, including **Dr. Taewan Kim**, **Dr. Manuela De Franco**, **Dr. Miguel Dosil**, **Dr. Jae Taek Oh**, **Dr. Rajesh Bera**, **Marta Martos Valverde**, and **Dr. Gaurav Kumar**, led by **ICREA Prof. Gerasimos Konstantatos**, have now proposed a new approach. By understanding how a shell made of zinc selenide (ZnSe) grows on InAs quantum dots and carefully controlling that process, they have **greatly improved the dots' light-emission efficiency**. The team has reported, in a study published in Nature Communications, a **PLQY above 55%**, surpassing the PLQY typically reported for comparable systems, and has used these quantum dots to make state-of-the-art InAs-based SWIR LEDs. ?

To synthesize the dots, the researchers first prepared InAs cores and treated them with zin chloride (ZnCl?). This treatment slightly etched the core surface, releasing some individual I and As atoms that then could participate in the ZnSe shell growth. As a result, the interfac between the core and the shell was formed more gradually, which mitigated strain an promoted shell growth. i¿½Previous studies have mainly focused on the final shell structu e. Our work, in contrast, shows that th**very early stage of shell growth is also critical**,i¿½ sa s Dr. Taewan Kim, first author of the articl

. The team also introduced a small amount of oxidation at the InAs surface. This oxidiz d interface helped to reduce the strain that develops as the ZnSe shell grows thicke . i¿½Oxidation is usually considered harmful to quantum dots because it can create def cts and reduce light emission,i¿½ explains Kim. i¿½But, in this ca**se, small and controlled amount of oxidation was actually beneficial**.i¿

? Finally, the researchers built LEDs using the InAs/ZnSe quantum dots as the light-emitti g layer. The devices simultaneously achieved long-wavelength emission, high efficiency, hi h radiance, and operational stability, setting **new state of the art for heavy-metal-free SWIR LEDs based on quantum dots.** i¿½Achieving high photoluminescence efficiency was only pa t of the challenge. We also needed to translate these properties into a working device, whe e charge injection and transport become equally important," says Dr. Manuela De Franco, w o led the device wor

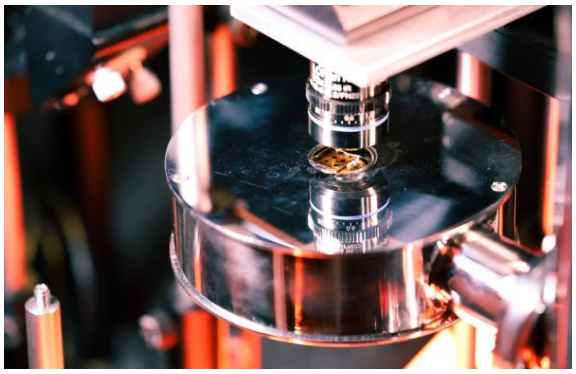
. Combined with emission around 1.5 micrometres, in the telecommunications waveleng h range, these results open interesting opportunities for heavy-metal-free SW R optoelectronics and offe**r clearer picture of how the core/shell interface controls the dots' final performance**.

Reference:

Kim, T., De Franco, M., Dosil, M. et al. Controlling the shell growth mechanism and interfacial oxidation of InAs/ZnSe quantum dots for shortwave infrared emission. Nat Commun **17**, 9969

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Close-up picture of the device. Credit: ICFO.