discrete, atomic-like structure of electronic states leads to a narrow ensemble emission linewidth of 20 to 80 meV at room temperature [defined as a full width at half maximum -> nextgen displays

Best cQD samples also achieve near-unity photoluminescence quantum yield (PLQY; the number of emitted photons per absorbed photon)

QDs feature a large surface-to-volume ratio, making them sensitive to their environment.

Surface programming (cQDs can be tethered to proteins, antibodies, or other biologic species and used as optically addressable biolabels)

Compared with organic LEDs (OLEDs), cQD-based LEDs offer narrower emission linewidths (<30 nm versus >60 nm for OLEDs) (Fig. 2E) and correspondingly higher color purity

Whereas cQD lasers are still at the stage of exploratory devices, lasers based on eQDs have already reached technological matu- rity (71). In particular, record-low thresholds (72) and high operating temperatures of up to 220°C (73) have been achieved by using III-V eQDs. eQD lasers have become a key component in silicon photonics, optical interconnects, telecommunication, and data centers (74).

Improvements in colloidal synthesis of HgTe cQDs, doping, and surface engineering led to the demonstration of mid-IR sensors with room-temperature photoresponse beyond 5 mm

In standard CMOS-based cameras, readout circuitry and photoactive elements coexist within the same layer, limiting the photodetection area (fill-factor) to ~30%. Top-surface integration of cQDs onto CMOS chips led to improved sensors with 100% fill-factor

The direct bandgap of cQDs also allowed for thinner photoactive films (~600 nm), reducing signal crossover from adjacent pixels compared with silicon back-surface–illuminated sensors.

In cQD photovoltaic devices, the energy of photogenerated excitons is harvested in the form of electrons and holes, which are collected and used to generate an electric current.

Early cQD solar cells relied on a dye-sensitized configuration as organic dye replacements. Electron-hole pairs were harvested by means of redox reactions and charge transport facilitated through TiO2 and electrolyte. Initial solid-state cQD PV devices used PbS cQDs embedded in a conducting polymer to enable charge transport

In contrast to traditional lens- and mirror-based concentrators, LSCs can operate equally efficiently for direct and diffuse light, making them well suited as large-area sunlight collectors for building integrated PVs installed as solar windows and solar sidings

The cQD large surface-to-volume ratio offers a path to increased reaction rates. Strain and defect engineering was shown to increase cQD photocatalytic activity

The artificial atom-like features of QDs triggered efforts to use them as quantum technology hardware, leveraging potential advantages such as ease of miniaturization, scalability, and integration

For optically active excitons in self-assembled QDs, the coherence time can be as long as nanoseconds; for optically inactive excitons, it may reach microseconds, similar to spins.

Ds are attractive as quantum light sources, providing emission of single as well as entangled photons with high fidelity (149). Ex-cellent performance parameters have been achieved, mostly by using eQD structures thus far. A key factor in that respect is the “silencing” of the quantum emitter environment—for example, by suppressing lattice vibrations and charge fluctuations. The first can be achieved with cryogenic cooling, whereas the second requires high material quality and separation from surfaces and surfactants located therein.

A QD in a high-quality optical resonator cavity is the basic unit of a single-photon source (Fig.6A) (150). After tailored pulsed excitation, theQD will ideally emit one and only one photon, which is called antibunching. The quality of antibunching can be characterized by mea- suring the second-order correlation function g(2) (t = 0), which should reach zero in case of perfect operation because it gives the probability of detecting simultaneously two photons (Fig. 6A, bottom). Over the years, the continuous improvement of In(Ga)As/GaAs eQD materials (151, 152) has led to the suppression of g(2) (t = 0) to less than 10−4 (153)

Photon indistinguishability exceeding 98% has been achieved for eQD devices

a general understanding of the relation between symmetry and the complex polarization spectra of excitons and excitonic complexes is still lacking.

A prominent C2v feature is the fine-structure splitting between the x- and y-polarized bright exciton states, induced by the exchange interaction

DARK STATE?

high technological and scientific interest as they ideally possess high C3v symmetry and currently are the onlynsystem providing a high density of emitters of polarization entangled photons [7, 12]. Moreover, the pyramidal QDs are site-controlled with extreme dot-to-dot uniformity in the spectral features [23–26], enabling rigorous analysis of very complex optical spectra, including the spectral patterns of QDs with various degrees of symmetry breaking.

the group theory approach for analyzing the fine structure patterns is very effective when dealing with high symmetry QDs.

electrons (e) and holes (h) confined in a QD under the influence of mutual Coulomb interactions form a large variety of exciton complexes. Exciton complexes have been identified and investigated for various QD systems, and for the most well-studied complexes, all the electrons and holes occupy the corresponding ground state levels, such as the single exciton X (1e1h), the biexciton 2X (2e2h), the negative trion X− (2e1h) and the positive trion X+ (1e2h)