Advancements in quantum dot-based light sources

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Research on the control of electron motion using semiconductor ultra-thin films traces its origins to the superlattices and quantum wells proposed by Dr. Leo Esaki in 1970 [1]. This work led to the development of quantum well lasers and high-mobility transistors, which have significantly contributed to the advancement of the IT industry. However, there was no discussion of quantum dots (QDs) in the 1970s. The concept of QDs as three-dimensional semiconductor hetero nanostructures was first introduced between 1981 and 1982 by the author and H. Sakaki with a particular emphasis on their application in lasers [2]. Since then, the author and his collaborators have advanced research on the physics and growth technologies of QDs, promoting the practical implementation of QD lasers. Meanwhile, various approaches have been explored for developing single-photon sources, a crucial component of quantum networks. The QDs offer several advantages, including the ability to integrate with photonic nanostructures and enable electrical excitation.

This presentation outlines recent advancements in QD-based light sources across a wide range of wavelengths and operating temperatures, with a particular emphasis on single-photon sources [3,4]. It covers high-quality single-photon sources based on III-As and III-P QDs, as well as the demonstration of GaN QD-based single-photon sources operating at temperatures up to 350 K, owing to their large biexciton binding energy [5]. The discussion also includes the CMOS-compatible integration of QD-based single-photon sources onto silicon chips for near-infrared wavelengths, including the C-band, achieved through transfer printing technologies [6]. Finally, we provide a brief overview of the current state-of-the-art in the QD lasers, focusing on their potential applications in photonic and electronic convergence technologies [7].

References

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