Experimentelle Physik 2

Seminar Festkörperphysik (CMP Seminar)

Aktuelle Probleme der Festkörperphysik für Studenten und Mitarbeiter
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AI Boom and Quantum Dot Lasers

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The rapid expansion of artificial intelligence (AI), driven by hyperscale data centers and accelerated computing, is placing unprecedented demands on optical interconnects. Bandwidth density, energy efficiency, thermal stability, and manufacturability have become critical constraints, pushing conventional InP quantum well laser technologies close to their physical and economic limits. In parallel, emerging sensing applications such as FMCW LiDAR impose similarly stringent requirements on laser coherence, stability, and tunability. In this context, quantum dot (QD) lasers are finally emerging as a key enabling technology across both communication and sensing domains.

The seminar will begin with an often-asked question: whether AI represents a speculative bubble, similar to the dotcom bubble of 2000, or a genuine technological boom. It will then provide a brief historical overview of QD laser development, from early academic concepts to industrial implementation. Particular attention will be given to the evolution of QD lasers at Innolume, where systematic work over more than two decades has focused on translating the intrinsic advantages of QDs into manufacturable, high-performance devices. This long-term development effort offers a useful perspective on why QD lasers are reaching technological maturity precisely at the moment when AI-driven applications demand their unique properties.

The talk will then review the fundamental characteristics of quantum dots, including unprecedented efficiency at elevated temperatures, tolerance to back reflection, low relative intensity noise, and superior reliability resulting from a high tolerance to defects and the absence of laser mirror degradation. Special emphasis will be placed on O-band lasers for pluggable optical transceivers and co-packaged optics platforms. QD DFB lasers, comb lasers, and a unique multiple wavelength ultra-low-noise semiconductor optical amplifier (SOA), exhibiting performance comparable to EDFAs, will be presented.

In addition, the seminar will discuss the advantages of QD lasers for FMCW LiDAR systems, where narrow linewidth, low phase noise, stable single-mode operation, and predictable frequency chirp are essential. The intrinsic robustness of QD lasers against temperature variations and optical feedback makes them promising candidates for scalable, robotics- and automotive-grade LiDAR architectures.

Beyond device physics, the seminar will address manufacturing and integration aspects, including yield, scalability, and compatibility with silicon photonics platforms. Finally, remaining challenges and future directions for QD lasers will be outlined, as AI and advanced sensing applications continue to redefine the requirements for photonic systems.