Quantum Dots for Green Quantum Technologies

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Universal self-organization at surfaces of semiconductors grown preferentially by MOCVD leads to the formation of self-similar quantum dots (QDs). Their electronic and optical properties are close to those of atoms in a dielectric cage. All their energy levels are however only twofold degenerate [1]. The few particle states like excitons are strongly Coulomb-correlated due to the carrier localization. Their energies depend on shape and size of the dots, such that positive, zero or negative biexciton binding energies and fine-structure splitting appear [2].

Applications of single, few and millions of QDs for novel Quantum Technologies will be elucidated.

a. Single QDs can be emitters of Q-bits on demand or entangled photons for future quantum cryptography systems. In electrically pumped RCLED structures, emission of q-bits at rates beyond 1 Gbit/s were shown [3, 4].

b. Hybridization of Flash and DRAMs, bringing together the advantages of both types of memories, is the "Holy Grail" of memories and ensures future memory development after the end of Moore's law. The goal of non-volatility (i.e. storage time > 10 years) can be achieved for the storage of holes in type II (InGa)Sb QDs embedded in a (AlGa)P matrix [5].

c. The demand for higher data rates in optical networks, requires novel ultra-high bit rate, energy efficient sources. QD Lasers based on GaAs emit up to the O-band at 1.3 μm, showing record low jth and complete temperature stability up to 80°C. Passive mode-locking generates pulses in the sub-ps range at repetition rates up to 90 GHz. The hat spectrum of one single laser of several tens of closely spaced narrow lines is thus a potential pulse source for bit rates up to ≈ 6 TBit/s using higher order modulation formats like DQPSK [6].

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