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Photoluminescence study of coupled quantum ring-quantum dot chain heterostructures

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Recent progress in nanostructure engineering allows to develop numerous opto-electronic devices based on quantum dots (QDs), quantum wires, quantum rings (QRs) such as low-threshold lasers, infrared photodetectors, solar cells, bio-sensors, spintronic gates, etc. For many applications, the nanostructures are needed to be ordered and be dense so as to increase the gain and efficiency of the devices incorporating them. We report here on a hybrid structure where InAs/GaAs QRs are grown on laterally aligned InGaAs/GaAs QDs, vertically stacked and forming a QD superlattice template where the strength of the electronic coupling is determined by the thickness of the GaAs barrier separating the dot layers.

This hybrid nanostructure reveals a sensitive photoluminescence (PL) emission to temperature variation and excitation intensity due to strong inter-dot and ring-dot coupling. It is revealed that the strong coupling between dot and ring species dramatically influenced the carrier and energy transfer both inter the chains as well as between the QRs and QD template. By combining effects of the temperature and excitation power intensity, this hybrid system has allowed the effective tuning of the PL gain within a 0.12 eV window. While QRs are coupled to the QD template and provide the deepest traps for the carriers, their emission survives even at high temperature. Due to complicated interplay of confinement, strain and geometry the non-trivial magneto-PL spectra has been observed. The oscillations of PL intensity together with the oscillations related to the AB interferences of QR emission as well as the magnetically induced transition where the heavy-hole states become the light-hole ones in magnetic field are revealed.