

## Blueshifts of the emission energy in type-II quantum dot and quantum ring nanostructures

### ABSTRACT

We have studied the ensemble photoluminescence (PL) of 11 GaSb/GaAs quantum dot/ring (QD/QR) samples over  $\geq 5$  orders of magnitude of laser power. All samples exhibit a blueshift of PL energy,  $\Delta E$ , with increasing excitation power, as expected for type-II structures. It is often assumed that this blueshift is due to band-bending at the type-II interface. However, for a sample where charge-state sub-peaks are observed within the PL emission, it is unequivocally shown that the blueshift due to capacitive charging is an order of magnitude larger than the band bending contribution. Moreover, the size of the blueshift and its linear dependence on occupancy predicted by a simple capacitive model are faithfully replicated in the data. In contrast, when QD/QR emission intensity,  $I$ , is used to infer QD/QR occupancy,  $n$ , via the bimolecular recombination approximation ( $I \propto n^2$ ), exponents,  $x$ , in  $\Delta E \propto I^x$  are consistently lower than expected, and strongly sample dependent. We conclude that the exponent  $x$  cannot be used to differentiate between capacitive charging and band bending as the origin of the blueshift in type-II QD/QRs, because the bimolecular recombination is not applicable to type-II QD/QRs.

**Keyword:** Bimolecular recombination; Capacitive models; Emission energies; Emission intensity; Excitation power; Linear dependence; Orders of magnitude; Quantum ring.