# Optically-induced charge depletion in type-II GaSb/GaAs quantum dots and rings

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There are many potential applications of type-II GaSb/GaAs self-assembled quantum dots (QDs) and quantum rings (QRs) including memories, solar cells and lasers. Blueshifts of the QD/QR emission energy, $E$, with increasing laser power, $P$, are commonly observed in photoluminescence measurements and result from capacitive charging [1]. However, at temperatures below 100 K, *redshifts* with increasing laser power have been observed and attributed to optically-induced charge depletion (OICD) [2]. OICD is caused by the interaction of photogenerated carriers with carbon acceptors in the sample. Here we report the remarkable observation of OICD at low temperatures (<20 K) in the wetting layer (WL), followed by the emergence of OICD above room temperature in the QD/QRs.

The sample was grown by molecular beam epitaxy on a (100) GaAs substrate and contains both GaSb QDs and QRs [3]. PL measurements were carried out at temperatures, $T$, of 2 to 400 K and laser power densities, $P$, of $10^{-1}$ to $10^{4}$ mWcm$^{-2}$. The magnitude of the OICD redshift in the WL *decreases* with increasing temperature [Fig. (a)]. In contrast, OICD is only seen in the QD/QRs at temperatures above 300 K [Fig (b)], and the magnitude of the redshift *increases* with increasing temperature. A simple rate equation model was created to replicate the OICD behavior seen in our data. It can be seen in Fig (c) that this model is successful in replicating the general behavior of OICD in the QD/QRs.

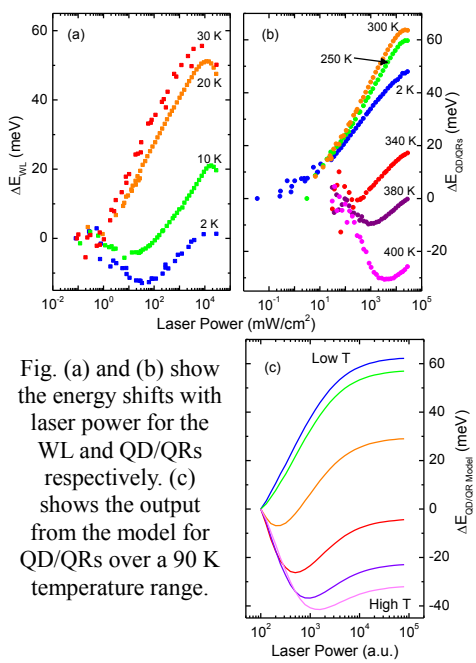


Fig. (a) and (b) show the energy shifts with laser power for the WL and QD/QRs respectively. (c) shows the output from the model for QD/QRs over a 90 K temperature range.

Our results indicate that the acceptor holes occupy the WL at T<20 K and migrate into the QD/QRs at T>300 K. The preferential occupation of QRs at T>300 K is promising for the implementation of GaSb/GaAs QRs in devices operating at room temperature. We tentatively suggest that highly strained QDs may account for the acceptor states at intermediate temperatures, with the majority of the PL emission in this sample arising from the less strained QRs.

[1] P. D. Hodgson et al., *'Type-II GaSb/GaAs quantum rings: charging mechanisms & the bimolecular recombination approximation'*, abstract submitted to MSS-16.

[2] M. Hayne et al., Phys. Rev. B 70, 081302(R) (2004).

[3] M. Ahmad Kamarudin et. al., Phys. Rev. B 83, 115311 (2011)