Comment on "Excitonic Recombination of Degenerate Two-Dimensional Electrons with Localized Photoexcited Holes in a Single Heterojunction Quantum Well"

In a recent letter, Folkes *et al.* [1] claimed the first definitive observation of the Mahan exciton in a single heterojunction quantum well (SHQW). In contrast to conventional heterojunctions, the sample used by Folkes *et al.* has an additional narrow QW (50 Å) placed at a separation of 50 Å from the active GaAs layer. The PL spectrum reported for this structure is found to be considerably blueshifted (by about 30 meV) in comparison with previous reports on modulation doped heterojunctions of varying width, from which it is well known that the emissions related to the 2D carriers occur at energies around the GaAs band gap ([2,3] and Ref. [7] in [1]). Folkes *et al.* [1] show no PL spectrum in this energy range, where it is relevant to their discussion. Instead they discuss the PL spectra at higher energies and propose a recombination process between electrons confined in the notch potential and holes localized either at the same AlGaAs/GaAs interface or alternatively 100–150 Å from the interface, as schematically illustrated in their Fig. 1. However, no holes will remain localized in the depletion region, but will be located at the opposite interface or in the flat-band region ([2,3] and Ref. [7] in [1]). Accordingly, we believe that the authors have misinterpreted the origin of their experimental data.

Based on the results presented in Ref. [1], we propose an alternative recombination mechanism for their structure, which is more consistent with existing ideas regarding recombination in a heterojunction. Electrons from the 2D gas recombine with holes confined in the narrow QW. The energy position of the QW recombination indicates a significant band gap renormalization (BGR). The hole confinement combined with BGR effects will explain the observed blueshift of the emission, in comparison with the more commonly studied heterostructures without a QW. We suggest that the peak at $\approx$1.550 eV in their Fig. 2 is due to a many-body Fermi edge singularity (FES). When the Fermi level approaches the next unoccupied $n = 2$ electron band, the scattering process becomes more efficient ([3] and Ref. [6] in [1]). For higher carrier concentration, the $n = 2$ band becomes populated and excitons related to the $n = 2$ band are formed (at $\approx$1.553 eV in their Fig. 2). This interpretation is consistent with the excitonic character of the $\approx$1.553 eV peak verified by the diamagnetic shift. These 2D related PL peaks remain at approximately the same energy position, when the electric field is varied. This fact is in accordance with previous results on the "traditional" heterostructures as illustrated in Fig. 1 [4]. Disregarding the energy position, these PL spectra exhibit striking similarities with the spectra shown by Folkes *et al.*

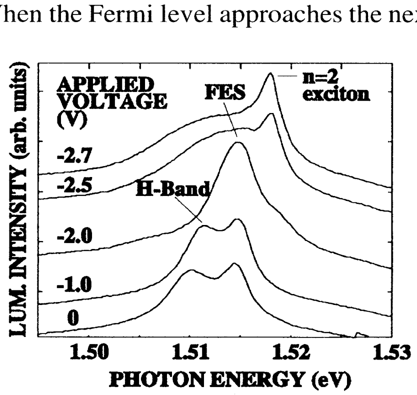

FIG. 1. Typical PL spectra for an antisymmetric GaAs/AlGaAs heterostructure with varying applied electric field.

A few additional points on the excitonic character of their spectra will be commented on. From the temperature dependent PL measurements, Folkes *et al.* derive an activation energy of 2.5 meV, which is concluded to be associated with hole localization neglecting alternative explanations. For instance, it seems reasonable to question whether this is not an indirect exciton binding energy. Furthermore, it is stated that "... a double peak PL spectrum, which is indicative of biexciton formation is observed." A double peak in PL is not by necessity a biexciton. Furthermore, a convincing diamagnetic shift for the high energy component is shown in Fig. 4(b) [1] consistent with an excitonic behavior, but the interpretation of the remaining structure as due to Landau level (LL) splitting is less convincing. The intensity of the LL related peaks are comparable with the noise level of the spectrum. Also, recent calculations [5], show that resolved LL splitting is only expected for high mobility samples.

In conclusion, we maintain that new insight on the topic of many-body effects could be derived from the novel structure presented. In this Comment we point out that there are a number of inconsistencies in the arguments which led the authors to identify the Mahan exciton recombination. We have suggested an alternative interpretation of the experimental data, which is more consistent with existing ideas regarding recombination in a SHQW.

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