What is the Origin of Very Strong Photoluminescence in ZnSe/BeTe Superlattices at Liquid Helium Temperature?

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Recently the type-II quantum structures have attracted considerable interest as the most promising material for observation of the excitonic condensation [1, 2]. In these systems photo-excited carriers, electrons and holes, are confined to spatially separated layers respectively resulting in a long radiation lifetime of the order of μsec. This means that electrons and holes are easily accumulated to become high-density and reach to thermal equilibrium states before their recombination.

ZnSe/BeTe superlattices have type-II band structure and especially large barrier height ~2eV for electrons and ~1eV for holes, respectively as shown in Fig. 1. In spite of the very short penetration depth of carriers to the neighboring layers, the type-II photoluminescence (PL) is strongly and efficiently observed at liquid helium temperature [3, 4]. On attempt to clarifying the mechanism and getting information related to high-density effects of excited states, PL measurements have been performed at various conditions; temperature, excitation light intensity and magnetic field. With increasing temperature the type-II PL drastically decreased and split into two components (A and B) as shown in Fig. 2(a). The peak B showed a tendency of saturation under high-density excitation, while the A showed a super-linear increase at 16K as shown in Fig. 2(b). No saturation feature of the type-II PL at 4.2K indicates that the A type transition is dominant in comparison with the B type. Applying magnetic field the A peak showed Zeeman splitting, diamagnetic shift and a polarization dependence, while the B showed no change in magnetic field as shown in Fig. 2(c). At 4.2 K the type-II PL is affected by magnetic field. These results also support that the A transition is dominant at lower temperatures. With decreasing temperature and increasing excitation density the PL become more sharp and steep but with a cut-off energy at 1.91eV where the PL spectra never exceed. These results suggest the possible occurrence of an excitonic condensation. The B type transition, however, is dominant in a n-doped ZnSe/BeTe quantum well suggesting the involvement in a high density charged exciton.

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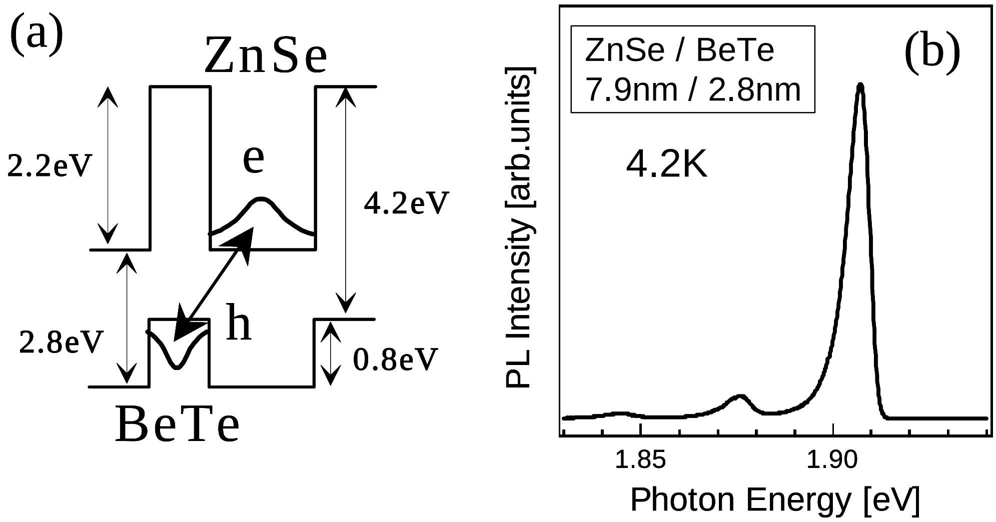

Figure 1. Band structure (a) and typical PL spectrum (b) of ZnSe/BeTe type-II superlattice.

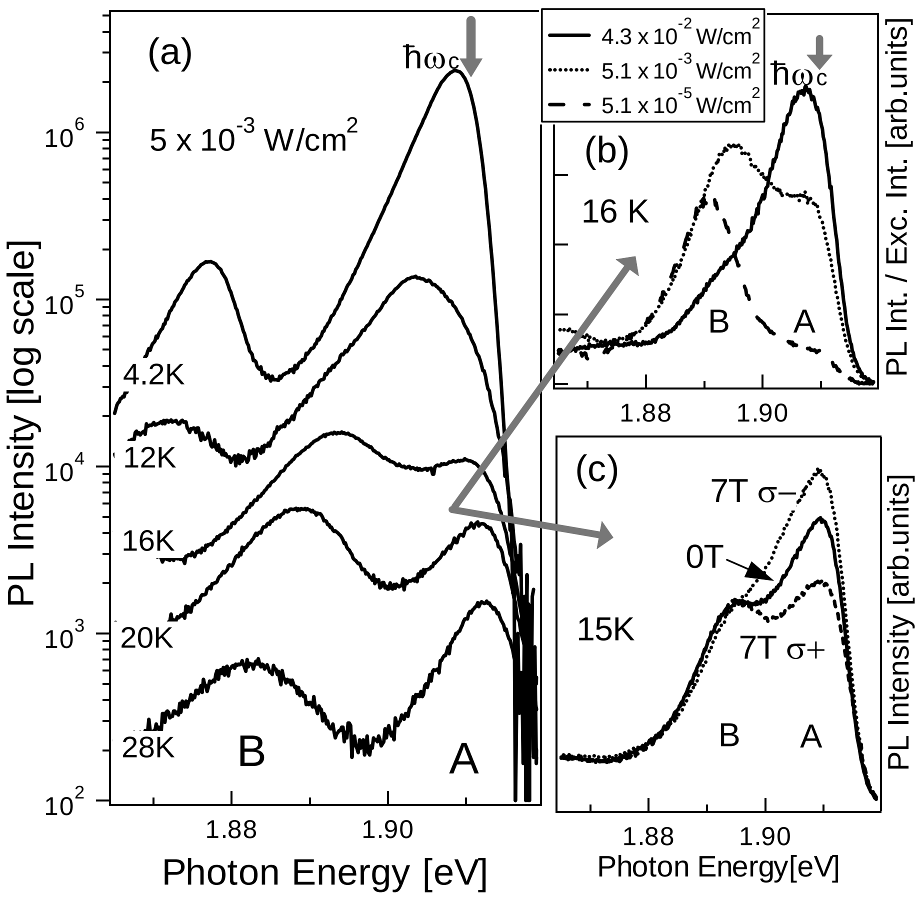

Figure 2. (a) Temperature dependence of type-II PL spectra. The main peak are divided into two components A and B at higher temperature regions. (b) Excitation intensity dependence of type-II PL at 16 K. The A peak shows super-linear increase. (c) Magnetic field dependence of type-II PL at 15 K. The A peak shows excitonic behavior, while the B peak is unaffected by a magnetic field.