Near-band-gap Optical Properties of Modulation-doped $CdTe/Cd_{1-x}Mg_xTe$ Multiple Quantum Well Structures

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Modulation-doped quantum wells (QWs) constitute a system exhibiting properties which may essentially differ from properties of their undoped counterparts. The source of differences is the presence of free carriers in the quantum wells which strongly influence optical response of the system to electromagnetic radiation and, of course, also change the low-frequency conductivity. In general, doping with donors or acceptors leads to, respectively, n-type or p-type gas of charged carriers confined by a two-dimensional potential. In the present case we consider only n-type modulation-doped CdTe-based quantum well structures. At low temperatures, the near-band-gap optical properties of low-doped structures are dominated by excitation or recombination of neutral excitons and negatively charged excitons (trions). In the case of a single quantum well, by increasing doping level, which results in increasing the concentration of a two-dimensional electron gas (2DEG) in a QW, one observes a gradual change of the shape of the luminescence spectrum from that showing sharp lines resulting from recombination of excitions and trions to a broad structure defined rather by a Fermi-edge singularity. Application of magnetic field, perpendicular to the plane of the 2DEG further modifies spectra. In the case of undoped QWs or a low density 2DEG, one observes splitting of excitons or trions levels and optical transitions between split levels according to the relevant polarization selection rules. When the concentration of free electrons is high enough, transitions between Landau levels in the conduction and the valence band dominate the spectra.

In the present work, we studied of photoluminescence and reflectivity of modulation-doped $CdTe/Cd_{1-x}Mg_xTe$ quantum well structures grown by a molecular beam epitaxy. Each of four samples studied comprised ten QWs. Within each sample, parametrs of QWs and the doping of each of them were nominally identical. The samples differed by the doping concentration and the width of the spacer which resulted in differences in the concentration of a two-dimesional electron gas (2DEG). The samples were studied at liquid-helium temperatures and in magnetic fields up to 9 T. A near-band-gap (at about 1.6 eV) photoluminescence was excited with a green laser light while the reflectivity (a halogen lamp was used) was observed in a broader spectral range between 1.6 and 2.5 eV, clearly showing also the spectrum of higher-energy transitions, absent in the luminescence spectra. The measurements allow us to discuss the evolution of the optical response (in the near-band-gap energies) of modulation-doped CdTe-based mutliple quantum well structures as a function of 2DEG concentration which seem to be the first result for this kind of II-VI quantum structures.

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