Single PbSe/CdSe quantum well studied by photoluminescence

M. Szot[1], S. Chusnutdinow[1], K. Dybko[1], B. Turowski[2], A.M. Witowski[3], L. Kowalczyk[1], M. Wiater[1], T. Wojtowicz[1] , T. Story[1], G. Karczewski[1].

[1] *Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, PL-02668 Warsaw Poland*

[2] *Faculty of Physics, Warsaw University of Technology, Pl. Politechniki 1, 00-661 Warsaw, Poland*

[3]*Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*

The quantum confinement effect in semiconductor heterostructures is intensively studied for about three decades. Nonetheless, most of the experimental investigations were focused on wide gap III-V and II-VI semiconductors, possessing their optical activity rather in region of visible light. However, the two-dimensional (2D) structures based on narrow gap semiconductors like PbSe with rock-salt structure are equally attractive due to their uncommon properties resulting from huge dielectric constant and small electron and hole effective masses. For PbSe the excitonic Bohr radius is as large as 50 nm what gives the opportunity to study the confinement effects in relatively large structures. Contrary, by decrease of the spatial extension, the increase of the energy gap in quantum region even 10 times as compared to 3D samples can be reached. Thus, heterostructures like PbSe/PbSrSe [1] were attracted the attention mainly due to the possible convenient practical applications in mid-infrared optoelectronics. But the new impulse for investigation of 2D PbSe structures has appeared when it was found, that proper addition of Sn transform the PbSe into the phase of topological crystalline insulator.
In this paper, we present the results of photoluminescence investigations of samples containing single rock-salt PbSe quantum well (QW) with wide gap barriers of zinc-blende CdSe. The samples were prepared using molecular beam epitaxy technique on GaAs (100) substrate. The PL measurement were performed at temperatures from 4 to 300K using 1064 nm line of pulsed YAG:Nd laser for excitation. For sample containing 70 nm QW we observe no luminescence at LHe temperatures. The emission from the sample starts at about 40 K and riches its maximum at 150K. The energy of this emission is shifted almost 100 meV into the higher energies as compared to the energy of edge emission for bulk PbSe. (E_g=146 meV at 4K). The observed blue-shift is as big as that predicted for 10 times thicker PbSe/PbSrSe quantum wells. The good matching of the lattice parameters for PbSe and CdSe (6.127 Å for PbSe and 6.086 Å for CdSe) suggests that observed shift can be attributed entirely to the quantum confinement effect. Thus, if we observe ground state transition in QW, the quantum confinement in PbSe/CdSe structures seems to be much stronger than in the case of PbSe/PbSrSe ones. At higher temperatures, the PL signal is split into two lines separated by ≈10 meV at 150 K. Both lines exhibit rather moderate linear polarization degree of the other of 20 % and linear dependence of their amplitude on power of excitation. The observed temperature behavior and splitting of the emission will be discussed considering the many valley band structures and effective mass anisotropy in PbSe as well as dark excitonic states expected in the case of PbSe quantum structures [2].

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