

Synchrotron radiation photoemission study of $Pb_{1-x}Cd_xTe$ crystal with local structure

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The high energy photoemission experiment was performed using the Tunable High Energy X-ray Photoemission Spectrometer (THE-XPS) at wiggler beam line station BW2 of the HASYLAB, Hamburg, Doris III synchrotron storage ring. Double crystal monochromator with crystal Si(111) works in energy range from 2,4 to 10keV with photon flux of about 5×10^{12} photons/s of monochromatic beam and with total energy resolution power of 0,5 eV for radiation energy around 3000 eV. The photoemission studies were performed at room temperature.

The crystals PbTe and CdTe are of different crystalline structure and their relative solubility is remarkably low. The PbTe belongs to the group of IV-VI narrow gap (0.23eV) semiconductor compounds and crystallizes in the six fold coordinated lattice of rock salt (lattice constant 6,462Å) while the CdTe belongs to the group of II – VI middle gap (1.45eV) semiconductor compounds and crystallizes in four fold coordinated zinc blend lattice (lattice constant 6.480 Å). The remarkable low relative solubility of PbTe and CdTe leads to the unexpected effects in a case of attempting to grow MBE layers of ternary alloy of these two crystals. In the case, nanostructures with a quantum dots of PbTe surrounded by CdTe or quantum dots of CdTe surrounded by PbTe were grown .

The paper presents comparison of high energy photoemission spectra of two kind of semiconductor samples. The one is ternary crystal of $Pb_{0,94}Cd_{0,06}Te$ [1, 2] with the frozen rock salt structure. In these crystal the crystalline local structure is expected to be created due to the differences of the radiuses size of Pb^{2+} (1.2 Å) and Cd^{2+} (0.97 Å) cation. The second one sample is the layer nanostructure $CdTe(6nm)/PbTe(6nm)/CdTe(40nm)/GaAs(0.5mm)$ grown in thermal equilibrium by Molecular Beam Epitaxy (MBE) method [2 - 4] were crystalline local structure is not expected to be created. The high energy photoemission spectra showed that for crystalline sample with local structure the electron binding energies of cations are higher (about +0.2eV) while for anion they are lower (about -0.01eV) than for layer. Obtained shifts of binding energies are of opposite sign for electrons of anions than of cation. The model of the created crystalline local structure collapse is proposed.

As a conclusion we can say that obtained electron binding energy differences are caused by the crystalline local structure in the crystal of $Pb_{0,94}Cd_{0,06}Te$.

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