GaAs/AlGaAs quantum wells grown by MBE near the GaAs/Zn(Mn)Se heterovalent interface formed on c(4x4)As GaAs surface

G.V. Klimko, E.A. Evropeytsev, S.V. Gronin, I.V. Sedova, S.V. Sorokin, S.V. Ivanov

Ioffe Physical-Technical Institute, Politekhnicheskaya 26, St. Petersburg 194021, Russia

The MBE grown hybrid III-V/II-VI structures have attracted much attention in the last few years because of their prospects for a number of optoelectronic applications and fundamental studies in spintronics. In particular, the hybrid structure with a diamagnetic AlGaAs/GaAs quantum well (QW) resonantly coupled to a paramagnetic ZnSe/ZnCdMnSe QW through a III-V/II-VI heterovalent interface (HI) has demonstrated the strong magnetic interaction [1], and a 60% spin injection has been observed from a ZnMnSe DMS injector to a double AlGaAs QW placed in the vicinity of such HI [2]. The above mentioned hybrid structures contain the thermodynamically equilibrium neutral GaAs/ZnSe HI with chemical band offsets (ΔE_C~170 meV) [1], and the interface was formed using high temperature (T_S=300°C) ZnSe MBE deposition on (2x4)As GaAs surface mediated by a controllable Se-decoration yielding a (2x1)Se reconstruction [3].

This paper presents studies of structural, optical, and electrical properties of hybrid structures with the AlGaAs/GaAs QW placed closely to the GaAs/Zn(Mn)Se HI formed in different ways on an As-rich c(4x4) GaAs surface. The studies of III-V/II-VI HI formation on c(4x4)As GaAs is of a great importance for the Be-containing hybrid structures (e.g. tunneling diodes for hybrid solar cells) because of the low growth temperature T_S=400-450ºC necessary for highly p-doped (Al)GaAs:Be to suppress fast Be diffusion and surface segregation [4]. Low T_S results in the c(4x4)As reconstruction of the as-grown III-V structure. The hybrid structures were grown on GaAs(100) substrates using a two-chamber MBE setup (SemiTEq, Russia). They contain two GaAs QWs with thicknesses of 10 nm and 6 nm (top), separated by a 40-nm-thick $Al_{0.37}Ga_{0.63}As$ barrier. The top barrier consists of 3.5 nm-thick AlGaAs capped with one monolayer (~ 0.3nm) of GaAs. Except for the c(4x4)As terminating reconstruction, the (2x4)As one was also used as a reference. The AlGaAs QW surface reconstructions were preserved during transfer to the II-VI growth chamber through UHV. The II-VI growth was initiated on both types of surface reconstructions by using either the standard low-temperature (LT) (250ºC) MEE of ZnSe after a 30s Zn pre-exposure [3,5] or the high-temperature (HT) MEE (or MBE) deposition of ZnSe (or MnSe) on the GaAs surface preliminary decorated by Se background flux until appearance of clear (2x1)Se reconstruction [3]. Continuous RHEED monitoring demonstrated absence of 3D growth mode at the II-VI growth which evidences formation of coherent interface in all the cases. Detailed information on the HI structural quality will be provided by TEM studies. The photoluminescence (PL) studies demonstrate that the initial GaAs surface reconstruction ((2x4)As or c(4x4)As) has no significant influence on PL intensity of the near-interface GaAs QW, whereas the ZnSe growth initiation does. In particular, PL completely decays in case of the c(4x4)As-Zn-LT-MEE interface and remains bright for the c(4x4)As-(2x1)Se-HT MEE (MBE) interface formation procedure, which confirms an importance of mixing As-Zn and Ga-Se bonds at HI leading to both a minimization of the local electric fields [6] and probably strong reduction of ΔE_C at the HI in the former case. Additionally, HT MEE growth of ZnSe has been found to provide the highest PL intensity from top GaAs QW in comparison with HT MBE one.

[1] A.A. Toropov et al., *Phys. Rev. B* **71**, 195312 (2005); [2] F. Liaci et al., *Phys. Stat. Sol. (c)* **9**, 1790 (2012); [3] I.V. Sedova et al., *Abstr. 17th Int. Conf. on MBE, Nara,* 2012, p. 251; [4] S.V. Ivanov et al., *J. Cryst. Growth* **108**, 661 (1991); [5] O.S. Miwa et al., *Appl. Phys. Lett.* **73**, 939 (1998); [6] A. Frey et al., *Phys. Rev. B* **82**, 195318 (2010).