Fundamental properties investigation of (Ga,Mn)As and (Ga,Fe)As LT-MBE layers

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We have investigated (Ga,Fe)As and (Ga,Mn)As layers, grown by LT-MBE. The alloy compositions were determined using high resolution X-ray diffractometry (XRD) followed by the in-situ Reflection High Energy Electron Diffraction (RHEED) [1]. The SQUID magnetometry have been used for the study the epi-layers evolution from the diamagnetism to the soft ferromagnetism with the increasing of the doping level. Photoreflectance (PR) measurements enabled the determination of the band gap (E_0) optical transitions in (Ga,Mn)As and (Ga,Fe)As. PR studies were supported by μRaman spectroscopy [2,3,4,5] and Angle Resolved Photoemission Spectroscopy (ARPES). We have observed the built-up of the Mn states on the GaAs valence band edge resulting in appearance of the additional below band gap optical transition for the *n*-type (Ga,Mn)As epitaxial layers.

The *n*-type – *p*-type transition in (Ga,Mn)As is combined with the merging of the Mn acceptor sub-band and the (Ga,Mn)As valence band. The paramagnetic – ferromagnetic transition is combined with the small blue shift of (Ga,Mn)As gap. Our results obtained for the ferromagnetic (Ga,Mn)As can be well explained by the contribution of the band gap renormalization, increasing of the strain and disorder with the increasing of Mn concentration, as well as by two main electronic effects: the Moss-Burstein band filling effect (gap's blue shift) and the band gap narrowing (gap's red shift) which usually exist in degenerate *p*-type semiconductors. The (Ga,Fe)As epitaxial layers do not reach the ferromagnetic phase because the Fe ions are not acceptor impurities and do not modify the valence band of GaAs host.

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