Epitaxial layers lift-off using MgTe sacrificial buffer

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Monocrystalline substrate is a key component for growth of thin layers by molecular beam epitaxy (MBE). The choice of the substrate is typically determined by the lattice constant and crystalline structure of the designed layer. However physical properties of substrates may significantly affect the experiments performed on epitaxial layers, e.g. opaque substrate limits the light transmission and contributes to the absorption. The problem of opaque substrate can be solved by a lift-off of epitaxial layers [1]. This work presents a new method of producing free-standing semiconductor layers verified for different systems: CdTe/ZnTe quantum dots (QD) with single Mn ions [2], (Cd,Zn,Mg)Te based microcavity with semimagnetic (Cd,Zn,Mn)Te quantum wells (QW) [3] and a MnTe layer. In each case on the GaAs substrate the MgTe sacrificial buffer was deposited before the proper structure and is of a particular importance.

Photoluminescence and reflectance at both room and helium temperatures reveal characteristic features for each system. Spectrum of typical observed QD contains lines related to neutral exciton, charged excitons and biexciton, some dots showed sixth-split transition what is characteristic for QDs with individual manganese ions. Microcavity shows characteristic stopband with sharp cavity mode interacting with a QW excitons and forming exciton-polaritons. Despite introduced hygroscopic MgTe layer our structures are stable in ambient atmosphere.

To separate the structure from the substrate, the sample is glued to a quartz glass and immersed in deionized water for 2 hours. After rinsing, MgTe layer is removed by water and the glass plate with structure is lifted-off from the substrate [2]. The images of the sample on the glass shows continuous surface of the area exceeding 2 mm^2. Optical measurements performed on QDs and microcavity after the process show that properties of examined structures stay qualitatively the same. For instance low temperature photoluminescence and reflectivity spectra of the microcavity demonstrate the existence of strongly coupled exciton-polariton modes, what confirms that Mg in Bragg mirror and cavity was not harmed despite long contact with water.

Only after lift-off it was possible to measure optical transmission through the samples. In the case of the microcavity observation of polaritons dispersions is consistent with the results obtained using other experimental methods, such as back illuminated photoluminescence or angle resolved reflectance. Moreover, the magnetooptical measurements allow us to observe giant Zeeman effect of polaritons, observed previously only on non-transmitting microcavities [4]. In the case of a MnTe layer it was possible to measure optical transmission only after lift-off which allowed to observe intraband transition quenched before by GaAs absorption edge.

Presented technique has been also used to free (Mg,Cd)Te sollar cells from their InSb absorbing substrate. That not only increase its efficiency but can also lead to integration of (Mg,Cd)Te cells into a high-efficiency, current-matched II-VI/Si tandem devices [5].

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