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Natural in-plane optical anisotropy of ZnSe/BeTe superlattices with no-common atom at the interfaces

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Abstract. Reflectivity and ellipsometry methods were applied to study optical properties of type-II ZnSe/BeTe superlattices. Natural in-plane optical anisotropy of the refractive and absorption indices has been found in the spectral range of direct excitonic transitions. The observed effects are interpreted in a model of optical anisotropy of heterostructures with no-common atom at the interfaces.

Recently it was found that in type-II ZnSe/BeTe superlattices with no-common atom at the interfaces photoluminescence signal is linearly polarized along a $[1\bar{1}0]$ direction with a polarization degree of 80%, in a spectral range of spatially indirect exciton transitions [1]. This effect is attributed to the low local symmetry of the single interface between two different zinc-blend type materials. Such an interface has C_{2v} symmetry instead of D_{2d} symmetry in the bulk that allows the observation of an anisotropy of the optical constants in the structure plane [2]. The lowering of the interface symmetry leads to a mixing of light-hole and heavy-hole states [3], which results in polarized photoluminescence of spatially indirect excitonic transitions, which are strongly localized near the interface. Polarized photoluminescence of spatially indirect excitonic transitions display intrinsic properties of the interface with no-common atom and can give no information about optical properties such as reflection and transition of the whole heterostructure.

One of the most common methods to study optical properties of heterostructures is reflection spectroscopy. However, this method is not sensitive enough to measure a small optical anisotropy in heterostructures with a low number of interfaces. In the present paper we use ellipsometry [4] to measure an optical anisotropy of ZnSe/BeTe superlattices with no- common atom at the interfaces. This method is extremely sensitive to the optical thickness of thin layers. It makes use of changes in the polarization of incident light when it is reflected from the surface of the sample.

The samples were grown by MBE on (100)-oriented GaAs substrates. During the growth procedure both interfaces were fabricated with a ZnTe transition layer. ZnSe/BeTe superlattice has type-II band alignment where electrons and holes are separated spatially in the subsequent layers. The period of the heterostructures was 150 Å and the width of the quantum wells was 50 Å. All studied heterostructures contained 20 periods. The band offset for holes is 0.9 eV and for electrons it is 2.3 eV. The period of the investigated structures (150 Å) is much less than the thickness of the whole superlattice (3000 Å). Therefore, we can describe the optical properties of this superlattice using an effective complex dielectric function $\varepsilon(\omega)$ [5].

By using the ellipsometry we have measured a spectral dependence of the complex dielectric function (refractive and absorption parts) of the superlattice in a spectral range

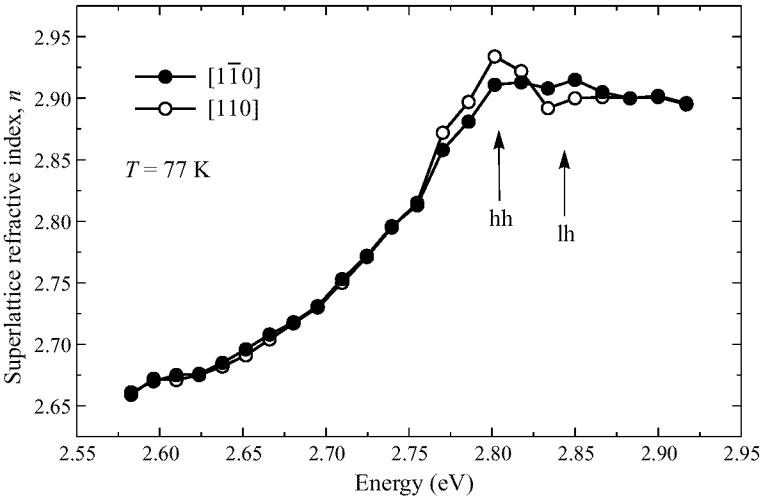

Fig. 1. Spectral dependence of the superlattice refractive index $n(\omega)$. Solid circles present the refractive index for the [1$\bar{1}$0] crystallographic direction. Open circles present it for the [110] crystallographic direction.

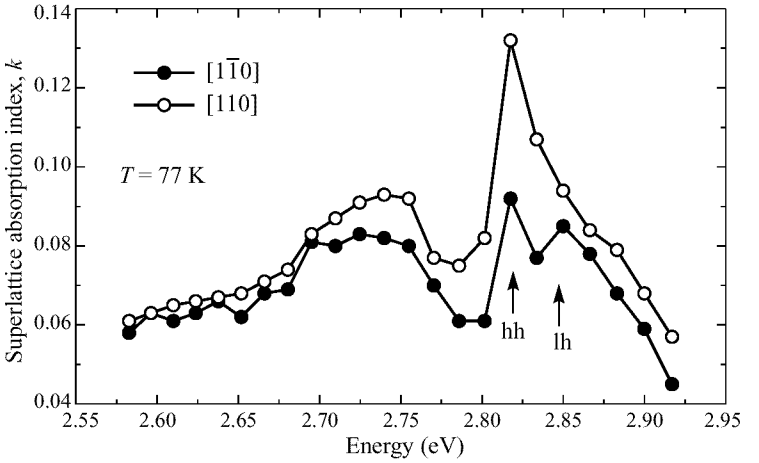

Fig. 2. Spectral dependence of the superlattice absorption index $k(\omega)$. Solid circles present the absorption index for the [1$\bar{1}$0] crystallographic direction. Open circles present it for the [110] crystallographic direction.

of spatially direct exitonic transitions. These measurements were performed at oblique incidence at 55.05° at temperature 77 K

Spectral dependencies of the refractive index $n(\omega)$ and absorption index $k(\omega)$ for [110] and [1$\bar{1}$0] crystallographic axis are presented at Fig. 1 and Fig. 2. In Fig. 1 one can see that the superlattice refractive index $n(\omega)$ is anisotropic in the spectral range from 2.755 to 2.833 eV and that this anisotropy has a resonant character with a maximum at 2.82 eV. The anisotropy of the superlattice absorption index $k(\omega)$ has also resonant character (Fig. 2).

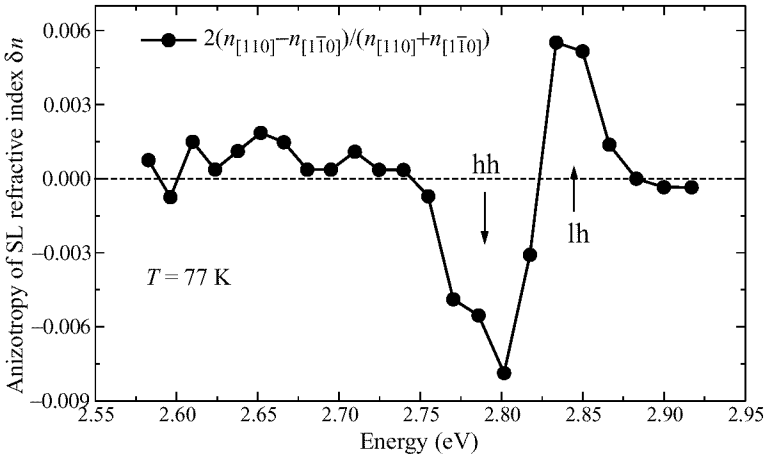

Fig. 3. Spectral dependence of the superlattice refractive index anisotropy. Sign of this anisotropy is different for heavy hole and light hole states.

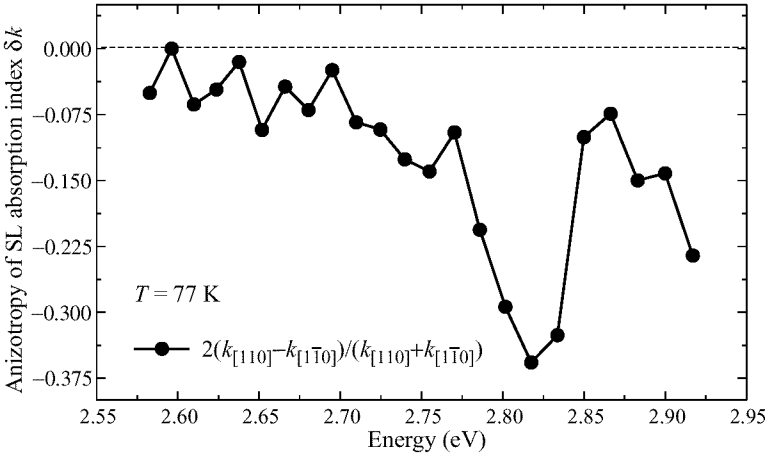

Fig. 4. Spectral dependence of the superlattice absorption index anisotropy. In this case sign of absorption index anisotropy is independed of the photon energy.

In Fig. 3 and Fig. 4 the anisotropy of the optical constants is presented. The sign of the anisotropy of the superlattice refractive index is different for heavy hole and light hole excitons (see Fig. 3). But for the absorption index (Fig. 4) the sign is independent of the photon energy. The maximum absolute value of measured refractive index anisotropy is 0.079 and for the absorption index is 0.357.

The obtained results allow us to conclude that the main part of the superlattice optical anisotropy corresponds with absorption index of the superlattice in the spectral range of the spatially direct excitonic transition.

Acknowledgements

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