Waveguide polaritons: interaction of quantum well exciton with electromagnetic mode of a planar waveguide

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A formalism based on non-local dielectric response theory and Green-function techniques has been developed to describe the interaction of quantum well excitons with an evanescent optical wave of a planar waveguide. Reflection spectra of a system in which quantum well placed behind a dielectric interface at which light experiences the total internal reflection have been calculated. It is shown that the spectral feature corresponding to the exciton resonance becomes much more pronounced if the angle of incidence is close to the critical angle of total internal reflection. A concept of a generalized Snell law has been applied to provide simplification of the formalism.

The formalism developed has been used to calculate the dispersion relations of planar dielectric waveguides containing quantum well excitons. Simple dispersion equation for polariton modes has been obtained. It is found that waveguide polaritons are formed, whose dispersion displays the classic anti-crossing behavoir at the exciton resonance frequency. For a quantum well placed at the anti-node of the fundamental TE mode of the GaAs/AlAs waveguide, the Rabi-splitting is calculated to be 6.55meV, with waveguide polaritons of lifetimes of ~7ps, corresponding to a decay length along the waveguide of ~0.5mm.

Electric field applied to the quantum well could change substantially mode spectrum of the waveguide polaritons, and modify the propagation of polariton modes. This effect could be used for the development of the new class of the electronic devices – “polariton modulator”. Such polariton modulator could be used for information processing and as tunable source of THz radiation.