Self-organization processes at exciton condensation in quantum wells

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A theory of exciton condensation in semiconductor double quantum wells is presented. By applying an electric field to the double quantum well, it is possible to force electrons and holes to different wells. As the result the exciton lifetime becomes by several order of magnitude longer than the lifetime of excitons in the bulk material. This circumstance allows creation of a large exciton density in order to study processes of exciton-exciton interaction. It is assumed that a condensed phase of excitons arises due to some (exchange) exciton-exciton attractive interaction and is described by several parameters. Non-equilibrium conditions, caused by finite value of exciton lifetime and a presence of pumping, are taking into account. For description of spatial distribution of condensed and gas phases two models of phase transitions are used: the model of nucleation and growth and the model of spinodal decomposition generalized on unstable particles. It is shown that due to finite value of the exciton lifetime the sizes of condensed phases are restricted and in two-dimensional case regions of condensed phase have a form of islands situated among excitonic gas. The structure arises due to an interaction between condensed phase islands through exciton concentration fields. The evolution of the islands of condensed phase with changing the temperature, pumping is studied. The theory is applied for the explanation of different periodical structures in luminescence spectra which were observed in several experiments last years. The influence of different type of external potential (for example, due to a presence of a window, slot in metallic electrode, so on) on the periodical structures is considered. It is shown that appearance of the structures occurs due to the non-equilibrium state of the system caused by the finite value of the exciton lifetime and the presence of pumping, and, therefore, it is the result of self-organization processes in a non-equilibrium system.