Effect of substrate orientation and external electric field on the bright exciton splitting in nanowire quantum dot molecule

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In this work we use atomistic tight-binding approach to study excitonic fine structure of nanowire quantum dot molecule formed by a double InAs disk-shaped nanowire quantum dot [1] embedded into a [001] or [111] oriented InP nanowire. We show that in a case of identical quantum dots, the quantum dot molecule inherits the symmetry properties of individual quantum dots. For example, in case of identical height quantum dots we don't observe the bright exciton splitting [2]. Next, we change the height of one of quantum dots. For the [001] grown quantum dot molecule this effectively lowers the overall symmetry from D_{2d} to C_{2v} and triggers the bright exciton splitting. On the contrary, for nanowire quantum dot molecules grown on [111] direction, despite different heights of quantum dots forming a molecule the double quantum dot retains its high C_{3v} symmetry. This again indicates no fine structure splitting. We complete our analysis by studies of the external electric field: in the case of [001] substrate the vertical electric field cancels the bright exciton degeneracy, whereas [111] quantum dot molecules are immune to the vertical field and show no fine structure splitting.
Finally, we conclude that nanowire quantum dot molecules combine the advantages of double quantum dots, such as suppression of spin relaxation [3] and wavelength tenability [4], with qualities on nanowire quantum dots [1] such as highly reduced fine structure splitting [2].

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