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Deep level transient spectroscopy evidence of point defects associated with InAs/GaAs quantum dots

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Investigation of the InAs/GaAs quantum dots (QDs) were carried out by deep level transient spectroscopy (DLTS). Two DLTS peaks corresponding to the quantized energy state in QDs and point defects associated with InAs/GaAs QDs, respectively, have been revealed. The defect level only appears in samples with quantum dots and therefore is related to the growth of the strongly stressed quantum dots. The level positions of the defects as well as the quantized energy levels have been determined.

Методом нестационарной спектроскопии глубоких уровней (НСГУ) исследованы квантовые точки (КТ) в системе InAs/GaAs. Обнаружены два пика НСГУ, соответствующие квантованному энергетическому состоянию КТ и точечным дефектам в системе InAs/GaAs. В образцах с квантовыми точками обнаруживается только уровень дефектов, поэтому он связывается с ростом сильно напряженных квантовых точек. Определены положения уровня дефектов и уровня квантованного энергетического состояния.

The MBE growing of self-organizing InAs/GaAs quantum dots using the Stranski-Krastanov method is well known [1, 2, 5, 6]. This method utilizes the stress relaxation between two materials with a large lattice mismatch to facilitate quantum dot (QD) formation of a rather high crystallographic quality. High-quality GaAs buffer layers can be obtained by epitaxial growing at a rather high temperature (~570°C). After the QD growing from relatively narrow band gap material InAs, a coating GaAs layer is usually grown to cover the QD one. To maintain the integrity of the QD layer, the covering layer is usually grown from the material of the same composition as the substrate whereon the QD layer has been grown, but at about 550°C. In such conditions the generation of point defects in the vicinity of the quantum dots is highly probable. In this case, the charge carrier emission from the quantum dots followed by carrier recapturing by defects can reduce considerably the quantum efficiency of the radiative recombination. Therefore, to optimize properties of semiconductor devices with quantum dots, it is extremely important to understand the role of deep states related to the defects associated with QDs.

The deep level transient spectroscopy (DLTS) is well known to be among the most effective methods for the characterization of deep energy states. This method has been used to characterize quantum wells, quantum dots, and arrays of vertically coupled InAs/GaAs QDs [1–6, 9, 10]. We have used this method with success to characterize the single layer of InAs QDs [7, 8]. In this report, we present experimental evidence of point defects associated with QDs obtained by means of DLTS technique in a multilayer structure.