Optical properties of artificial and self-organized InGaAs/GaAs quantum dots obtained on non-conventional GaAs surfaces

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In the past few years, much attention has been devoted to the study of three-dimensional (3D) coherent islands structures referred to as quantum dots (QDs). These structures have mainly been obtained in high lattice-mismatched systems such as Ge/Si (100), InAs/GaAs (100), InGaAs/GaAs (100) and InP/InGaP (100). In such systems, nanoscaled islands organize themselves during growth, following the Stranski-Krastanov (SK) growth mode transition, therefore avoiding any type of contamination due to post-growth ex-situ processing steps. The morphologic characteristics of these islands, such as height, density and size distribution, can be adjusted in a certain range with appropriate growth conditions. However, as a result of the random island formation, a significant nonuniformity is unavoidable, which leads to a breadth of the optical emission line, undesirable for the application of such structures in optoelectronic devices.

Much progress toward the direct fabrication of QDs quantum structures has been accomplished in recent years. Electron beam lithography (EBL) and reactive ion etching or crystallographic wet etchants have been used to fabricate arrays of nanostructures with controlled sizes. However, the interface quality was the limiting for the optical properties, particularly in the case of the InGaAs/GaAs system. The possibility of the use of non-(100) surfaces as substrates for epitaxial growth of semiconductor heterostructures, can improved the fundamental material properties such as: growth mechanisms, surface kinetics, and impurity incorporation at interfaces. The fact of low impurity incorporation at interfaces in (311) semiconductor structures, motivated the use of this surface for the direct QDs fabrication.

In this work we studied the optical properties of InGaAs/GaAs obtained by the direct fabrication using electron beam lithography and by Stranski-Krastanov process during the molecular beam epitaxy. Both EBL and SK quantum dots were obtained from (311) GaAs substrates. The photoluminescence was used to investigate the influence of the substrate orientation on the formation of the QDs and the presence of defects at the interfaces.