IOP Publishing

Journal of Physics D: Applied Physics

J. Phys. D: Appl. Phys. 49 (2016) 255304 (7pp)

doi:10.1088/0022-3727/49/25/255304

Relaxation of ferroelectric states in 2D distributions of quantum dots: EELS simulation

C M Cortés[1], L Meza-Montes[1], R E Moctezuma[2] and J L Carrillo[1]

[1] Instituto de Física, Benemérita Universidad Autónoma de Puebla, Apartado Postal J-48, Puebla 72570, Mexico

[2] Instituto de Física de la Universidad Autónoma de San Luis Potosí, Mexico

E-mail: lilia@ifuap.buap.mx

Received 29 January 2016, revised 27 April 2016
Accepted for publication 3 May 2016
Published 23 May 2016

Abstract

The relaxation time of collective electronic states in a 2D distribution of quantum dots is investigated theoretically by simulating EELS experiments. From the numerical calculation of the probability of energy loss of an electron beam, traveling parallel to the distribution, it is possible to estimate the damping time of ferroelectric-like states. We generate this collective response of the distribution by introducing a mean field interaction among the quantum dots, and then, the model is extended incorporating effects of long-range correlations through a Bragg–Williams approximation. The behavior of the dielectric function, the energy loss function, and the relaxation time of ferroelectric-like states is then investigated as a function of the temperature of the distribution and the damping constant of the electronic states in the single quantum dots. The robustness of the trends and tendencies of our results indicate that this scheme of analysis can guide experimentalists to develop tailored quantum dots distributions for specific applications.

Keywords: quantum dots distributions, ferroelectric relaxation time, Bragg–Williams approximation, electron energy loss spectroscopy

(Some figures may appear in colour only in the online journal)

1. Introduction

The knowledge and possible manipulation of the electronic relaxation time have been a subject of fundamental relevance in many areas of condensed matter physics, quantum optics and information technology. The decay times of quantum states is closely related to the quantum coherence lost whose control may have important applications in the field of quantum computation, particularly in the preservation of characteristic parameters and those of their 2D distribution. The generation of entangled states in quantum dot systems, the observation of their decoherence in times of the order of a picosecond as well as the transfer of coherence from a quantum macroscopic state have been demonstrated several years ago [1–4]. Presently it is possible to design these nano-scale systems that behave as artificial atoms, in the sense that they posses a well defined and controllable spectrum, at least at certain extent [5, 6].