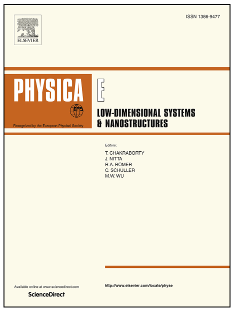
Accepted Manuscript



Curvature effects on the electronic and transport properties of semiconductor films

F.F. Batista, Jr., Andrey Chaves, D.R. da Costa, G.A. Farias

PII: S1386-9477(17)31606-5

DOI: 10.1016/j.physe.2018.02.004

Reference: PHYSE 13043

To appear in: *Physica E: Low-dimensional Systems and Nanostructures*

Received Date: 17 October 2017

Revised Date: 15 January 2018

Accepted Date: 4 February 2018

Please cite this article as: F.F. Batista Jr., A. Chaves, D.R. da Costa, G.A. Farias, Curvature effects on the electronic and transport properties of semiconductor films, *Physica E: Low-dimensional Systems and Nanostructures* (2018), doi: 10.1016/j.physe.2018.02.004.

Curvature effects on the electronic and transport properties of semiconductor films

F. F. Batista Jr.[a,b], Andrey Chaves[a], D. R. da Costa[a,*], G. A. Farias[a]

[a]*Departamento de Física, Universidade Federal do Ceará, Caixa Postal 6030, 60455-900, Fortaleza, Ceará, Brazil*
[b]*Departamento de Ensino, Instituto Federal de Educação, Ciência e Tecnologia do Cearaá, 62320-000 Tianguá, Ceará, Brazil*

Abstract

Within the effective mass approximation, we study the curvature effects on the electronic and transport properties of semiconductor films. We investigate how the geometry-induced potential resulting exclusively from periodic ripples in the film induces electronic confinement and a superlattice band structure. For fixed curvature parameters, such a confinement can be easily tuned by an external electric field, hence features of the superlattice band structure such as its energy gaps and band curvature can be controlled by an external parameter. We also show that, for some values of curvature and electric field, it is possible to obtain massless Dirac bands for a smooth curved structure. Moreover, we use a wave packet propagation method to demonstrate that the ripples are responsible for a significant inter-sub-band transition, specially for moderate values of the ripple height.

Keywords:
Bent semiconductor films, Electronic properties, Transport properties
PACS: 73.21.Hb, 73.63.Nm, 73.43.Cd

1. Introduction

Recent experiments have demonstrated the possibility of obtaining thin flexible semiconducting films.[1] For instance, R. Alston *et al* investigate some effects of transparent amorphous oxide semiconductor thin-film transistors for flexible electronic applications [2], Y. H. Kim *et al* report a general method for forming high-performance and operationally stable flexible metal-oxide semiconductors at room temperature [3], and K. Nomura *et al* show a method to fabricate transparent flexible thin-film transistors [4]. This renewed the interest in investigating quantum confinement, electronic and transport properties in curved planes. In fact, curvature effects have been extensively discussed both experimentally and theoretically in the context of V-groove quantum wires, as reported in Refs. [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18]. Such a system consists of a bent semiconductor heterostructure. In this case, electrons are mostly confined in the higher curvature region, rather than in the whole inner semiconductor plane, as expected for a conventional heterostructure. However, curvature is not the only effect involved in the electron confinement in v-groove wires: the high curvature regions in these systems also usually exhibit larger width, which, alone, would also induce electronic confinement. Notice that if there is a region of larger width, the ground state energy level is lower in this region and, consequently, the charge carriers will be confined there, as a pure quantum effect. On the other hand, the curved membranes considered here have no reason *a priori* to exhibit non-uniform width in the curved region. Therefore, it becomes very interesting to investigate separately the effect of the curvature on the behaviour of electrons confined in a curved plane.

In this paper, we systematically explore how the curvature affects the electronic and transport properties of semiconductor rippled films. We consider two different bent quantum wires: circular and Gaussian-like shapes connected with normal in-plane parts. In Sec. 2, we present the general the-

*Corresponding author
Email address: diego_rabelo@fisica.ufc.br (D. R. da Costa)