AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ENGINEERING PHYSICS AND MATHEMATICAL DEPARTMENT

QUANTUM ELECTRON DYNAMICS OF SOME NANODEVICES

A thesis Submitted in Partial Fulfillment of the Requirements of the Degree of master in Engineering Physics

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STATEMENT

This thesis is submitted as partial fulfillment of the requirement of M.Sc. degree in Engineering Physics, Faculty of Engineering, Ain-Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or qualification at any other scientific entity.

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LIST OF PUBLICATIONS

[1] H. A. El-Demsisy, M. D. Asham, D. S. Louis, A. H. Phillips, "Coherent Photo-Electrical Current Manipulation of Carbon Nanotube Field Effect Transistor Induced by Strain", Open Science J. Modern Physics 2(3), pp.27-31 (2015).

[2] H. A. El-Demsisy, M. D. Asham, D. S. Louis, A. H. Phillips, "Strain Effect on Transport Properties of Chiral Carbon Nanotube Nanodevice", International Journal of Nanoscience and Nanoengineering, 2(2), pp. 6-11 (2015).

[3] H. A. El-Demsisy, M. D. Asham, D. S. Louis, A. H. Phillips, "Thermoelectric Seebeck and Peltier effects of single walled carbon nanotube quantum dot nanodevice", Carbon Letters (Korean Science), Vol. 21, pp. 8-15 (2017).

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LIST OF SYMBOLS

AND

ABBREVIATIONS

a_1 *and* a_2	unit vectors in real space
n and m	Chiral indices
C_h	Chiral vector
k	wave vector
r	real space lattice vector
C_q	quantum capacitance per unit length
L_K	kinetic inductance per unit length
L	length of the CNT
V_{ac}	Amplitude of the ac-field
ω	Angular frequency
I	electric current
$\Gamma_{withphoton}(E)$	Photon-assisted tunneling probability
$f_{FD(s)}$&$f_{FD(d)}$	Fermi-Dirac distribution functions corresponding to source and drain leads
V_{sd}	bias voltage

E	energy of tunneled electrons
e	electronic charge
h	Planck's constant
C_{CNT}	Capacitance of the carbon CNT Quantum dot
C	coupling capacitance between CNT quantum dot and the leads
V_g	Gate voltage
ħω	Energy of the induced photon
$J_{\acute{n}}$	Bessel function
a	lattice constant
T	average temperature
γ_0	Nearest neighbor hopping integral
ε	Induced strain
d	diameter of CNT
Δ	thickness of CNT
E_F	Fermi-energy
V_b	Barrier height at the interface between CNT and leads
N	number of tunneled electrons

B	applied magnetic field
m*	effective mass of the charge carrier
E_g	strained band gap energy
b	linear change in the transfer integral with a change in bond length due to strain
R	radius of the carbon nanotube
θ	Chiral angle
S	Seebeck coefficient
Π	Peltier coefficient
CNTs	Carbon nanotubes
SWCNT	Single wall carbon nanotube
MWCNT	Multi wall carbon nanotube

Thesis Summary

The purpose of the current thesis is to explore the characteristics of quantum carrier transport of a single walled carbon nanotube quantum dot field-effect-transistor (SWCNTFET) subjected to both a magnetic field and an ac-field (mid infrared region). The effect of tensile strain for zigzag, chiral and armchair SWCNTs will be taken into consideration. Also, it is interesting to investigate the thermoelectric effect, that is, Seebeck and Peltier coefficients in the present different types of strained single walled carbon nanotube quantum dot field effect transistor (SWCNTFET) under the influence of an ac-field with frequency in the mid infrared region and magnetic field. This nanodevice can be modeled as follows: SWCNT in the form of quantum dot is connected to two metallic leads. These two metallic leads operate as a drain and a source. In this three-terminal device, the conducting substance acts as the gate electrode. Governing the Switching and the electrostatics of the carbon nanotube channel is realized by using another metallic gate. The back gate controls the substances at the carbon nanotube quantum dot/metal contact. Landauer-Buttiker formula using to deduce the electric current. Also by using the WKB approximation method, the photon-assisted tunneling probability is deduced. The strained band gap energy for all types of SWCNT is expressed in terms of the induced tensile strain. This band gap energy depends on the chiral indices for every type (armchair, zigzag, chiral) of the single walled carbon nanotube. In our calculations, we consider different chiral indices for every type of SWCNT.

Numerical calculations are performed for the strained energy band gap for zigzag, chiral and armchair SWCNTs. Also, the chiral angle and