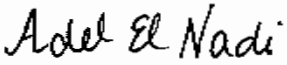
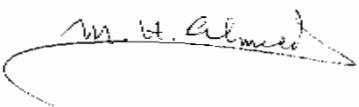


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Semicuductor Multiple Quantum Well Lasers"

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of M.Sc. in electrical Engineering.

The work included in this thesis was carried out by the author in the department of Electronic and Communications Engineering. Ain Shams University from December 1990 to December 1993.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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SEMICLASSICAL CALCULATION OF THE GAIN IN SEMICONDUCTOR
MULTIPLE QUANTUM WELL LASERS

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

BY

Eng. Ayman Mohamed Abdel-Moneim El-Sayed

A THESIS

Submitted in partial fulfillment for

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in Electrical Engineering

Electronics and Communications

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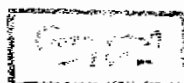
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LIST OF SYMBOLS

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A	vector potential
A_{21}	Spontaneous emission rate between levels 1 & 2
B	Einstein coefficient for stimulated emission
B_{eff}	effective recombination constant of semiconductor material in the case of QWL
c	light velocity in free space
D_n, D_p	electron and hole diffusion constants
e	Electron charge
E_g	Energy gap
E_{nx}	nth quantized energy level in the x-direction
E_c	Energy measured from the conduction band edge
E_v	Energy measured from the valence band edge
E_{fc}	Quasi fermi level for electrons
E_{fv}	Quasi fermi level for holes
$E_n(t)$	Fourier components of electric field in frequency domain
f	frequency
f_c	fermi dirac probability distribution for electrons
f_v	fermi dirac probability distribution for holes
$F_{\omega\beta}(x)$	normalized electric field distribution in x direction of the optical mode having angular frequency ω and probagation constant β
g	optical gain of the medium
g_{mod}	modal optical gain
g_{th}	threshold gain
h	Plank's constant

H	magnetic field intensity
H	Hamiltonian of carriers
H_0	Hamiltonian of the carriers in absence of electromagnetic field
H'	perturbation hamiltonian due to external field
J	current density
J_{macro}	macroscopic current density
j	microscopic current density operator
J_{th}	Threshold current density
$k_{x,y,z}$	The wave vector components in x,y and z direction
K	Poltzman's constant
L_a	width of the active layer
m_c	Effective mass of electrons in the conduction band
m_v	Effective mass of holes in the valence band
$ M $	density matrix of transition probability
n	Refractive index of the medium
N	carrier distribution
N_t	transparency carrier density
N_{th}	Threshold carrier density
$P(\hbar\omega)$	incident photon density per unit energy
$p(z,t)$	polarization density
P_{macro}	macroscopic polarization density
$p_n(t)$	Fourier component of polarization density in frequency domain
r_{st}	stimulated emission rate
$r_{ }$	position vector in the plane of interface between layers
R_{ch}	Transition probability for electrons from conduction to valence band

R	mirror or facet reflectivity
S	photon flux
T	Absolute temperature
t	time
u_k	Bloch wave function
$U_n(z)$	Fourier component of electric field in k-domain
v_g	Group velocity of the mode
$V(x)$	potential energy distribution
V_{int}	interaction energy of an atom with external electric field
x	Aluminium fraction in Al Ga As
$\gamma_{n,m}^{wp}$	overlap integral of nth electron sublevel and mth hole sublevel wavefunctions with electric field distribution
x,y,z	position coordinates
$\alpha_{ac,ba}$	optical loss in bulk material of active and barrier regions
β	propagation constant in the longitudinal direction
Δ	split off energy
ϵ_0	permittivity of free space
ϵ_r	relative permittivity of the medium
ϕ	envelope of the carrier wave function in
Γ_g	optical confinement factor of the optical mode
Γ	state decay matrix
γ	fraction of spontaneous emission coupled to the mode
$\gamma_{a,b}$	decay rate of states a & b
ψ	carrier wave function
λ	excitation rate matrix
μ_0	permeability of free space
μ	matrix element of dipole moment
μ_n, μ_p	electron and hole mobilities

$\langle \mu \rangle$	expectation value of the dipole moment
ρ	density matrix
$\rho_{aa}, \rho_{ab}, \rho_{ba}, \rho_{bb}$	elements of density matrix
ρ'	density matrix in absence of electric field with zero injected current
ρ''	density matrix in absence of electric field under injected current condition
ρ_c	energy density of states of electrons in the conduction band
ρ_v	energy density of states of holes in the valence band
ρ_{red}	reduced density of states
ρ_{qw}	density of states in quantum well structure
σ	conductivity of the medium
τ_n	carrier life time
τ_p	photon life time
τ_{in}	intraband relaxation time
ω	angular frequency
ω_n, ϕ_n	angular frequency and phase of the nth Fourier component of electric field or polarization density
Ω_n	nth circular frequency of a passive Fabry-Perot cavity
χ	complex susceptibility of the medium

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