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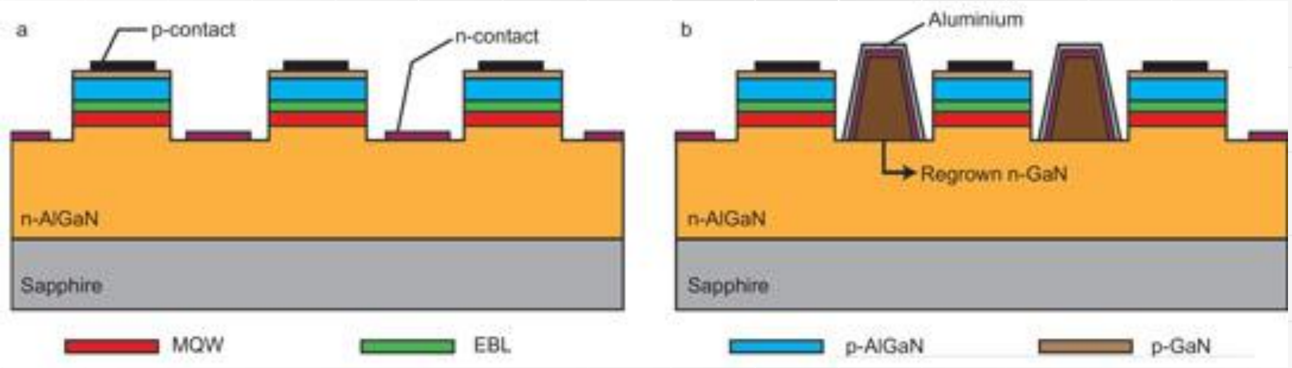
Advanced Optoelectronic project



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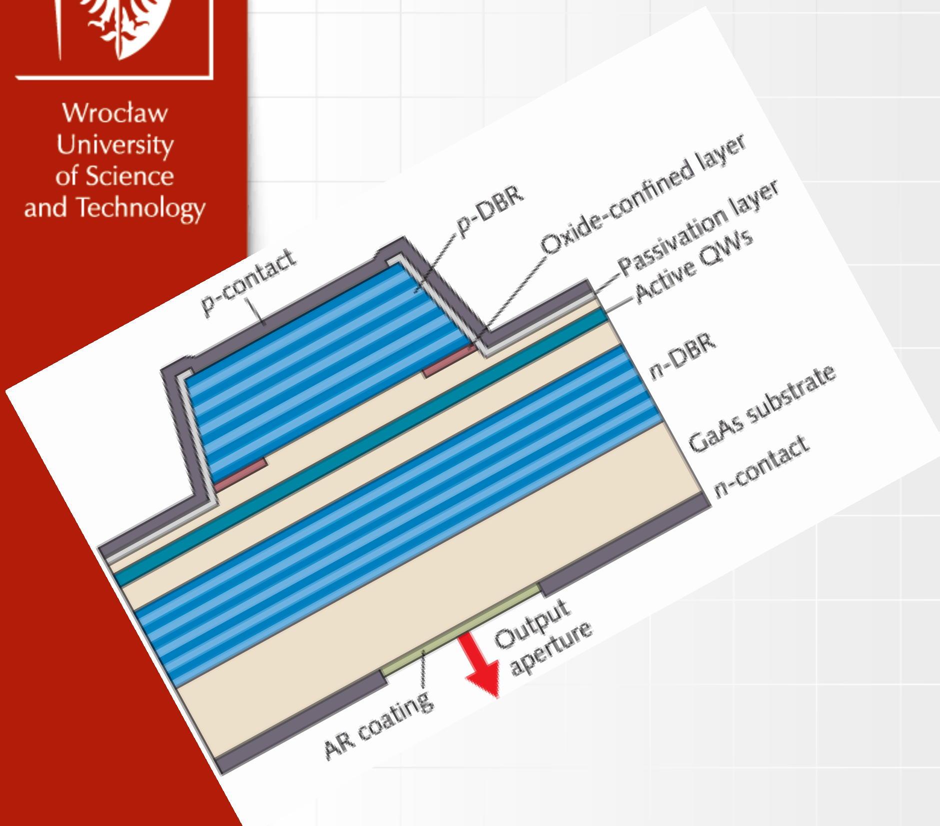
Advanced Optoelectronic project

Introduction part II



Simulation software by:

Crosslight Software Inc.

http://crosslight.com/

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Wrocław University of Science and Technology

Wrocław 2018

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Introduction

- LED structure
- .sol file
- MSM structure
- .layer and .sol files

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LED structure

Defining the device structure – cross section

1 μm - $Al_{0.5}Ga_{0.5}As$ - $p=1.0\times10^{24}$ m^{-3}
0.2 μm - GaAs - undoped; active region
1 μm - $Al_{0.5}Ga_{0.5}As$ - $n=1.0\times10^{24}$ m^{-3}

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.sol file

Defining the device structure – test1.sol file

```
$file:test1.sol
begin
 load_mesh mesh_inf=test1.msh
 include file=test1.mater
 include file=test1.doping
 output sol_outf=test1.out
 newton_par damping_step=5. max_iter=100 print_flag=3
 use_sor max_iter=3000 print_sor=noprint
 init_wave &&
   length= 0.2000E+03 backg_loss=500. &&
   boundary_type=[2 2 1 1] init_wavel= 0.8300E+00 mirror_ref=0.32 &&
   wavel_range=[ 0.8100E+00 0.8500E+00]
 equilibrium
 newton_par damping_step=1. print_flag=3
 scan var=voltage_1 value_to= -0.1345E+01 print_step= 0.1345E+01 &&
   init_step= 0.2689E+00 min_step=1.e-5 max_step=0.5
 scan var=current_1 value_to= 0.2500E+03 print_step= 0.2500E+03 &&
   init_step= 0.2500E+01 min_step=1.e-5 max_step= 0.2500E+02
end
```

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.sol file

Defining the device structure – test1.sol file

```
$file:test1.sol
begin
load_mesh mesh_inf=test1.msh
include file=test1.mater
 include file=test1.doping
output sol_outf=test1.out
```

The **.msh** file will be loaded into simulation data.

The different files with material information will be merged with input data.

Definition of base name for output data files.

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.sol file

Defining the device structure – test1.sol file

Define a basic 1D mode solver.

```
newton_par damping_step=5. max_iter=100 print_flag=3
use_sor max_iter=3000 print_sor=noprint
init_wave &&
  length= 0.2000E+03 backg_loss=500. &&
  boundary_type=[2 2 1 1] init_wavel= 0.8300E+00 mirror_ref=0.32 &&
  wavel_range=[ 0.8100E+00 0.8500E+00]
```

Defines the boundary conditions for the waveguide as well as other critical parameters for the device (length, mirror reflectivity, background losses, etc...)

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.sol file

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Defining the device structure – test1.sol file

It calls the Newton solver to get the initial solution of the device under thermal equilibrium conditions: this means only the Poisson equation is solved and the net current is zero for both electrons and holes. This is a required first step before bias can be applied.

It calls the Newton solver and find the state of the device under bias.

The variable controls which electrode is biased as well as the type of bias which is applied

```
equilibrium
newton_par damping_step=1. print_flag=3
scan var=voltage_1 value_to= -0.1345E+01 print_step= 0.1345E+01 &&
  init_step= 0.2689E+00 min_step=1.e-5 max_step=0.5
scan var=current_1 value_to= 0.2500E+03 print_step= 0.2500E+03 &&
  init_step= 0.2500E+01 min_step=1.e-5 max_step= 0.2500E+02
end
```

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MSM structure

Defining the device structure – cross section

Simulation software by:

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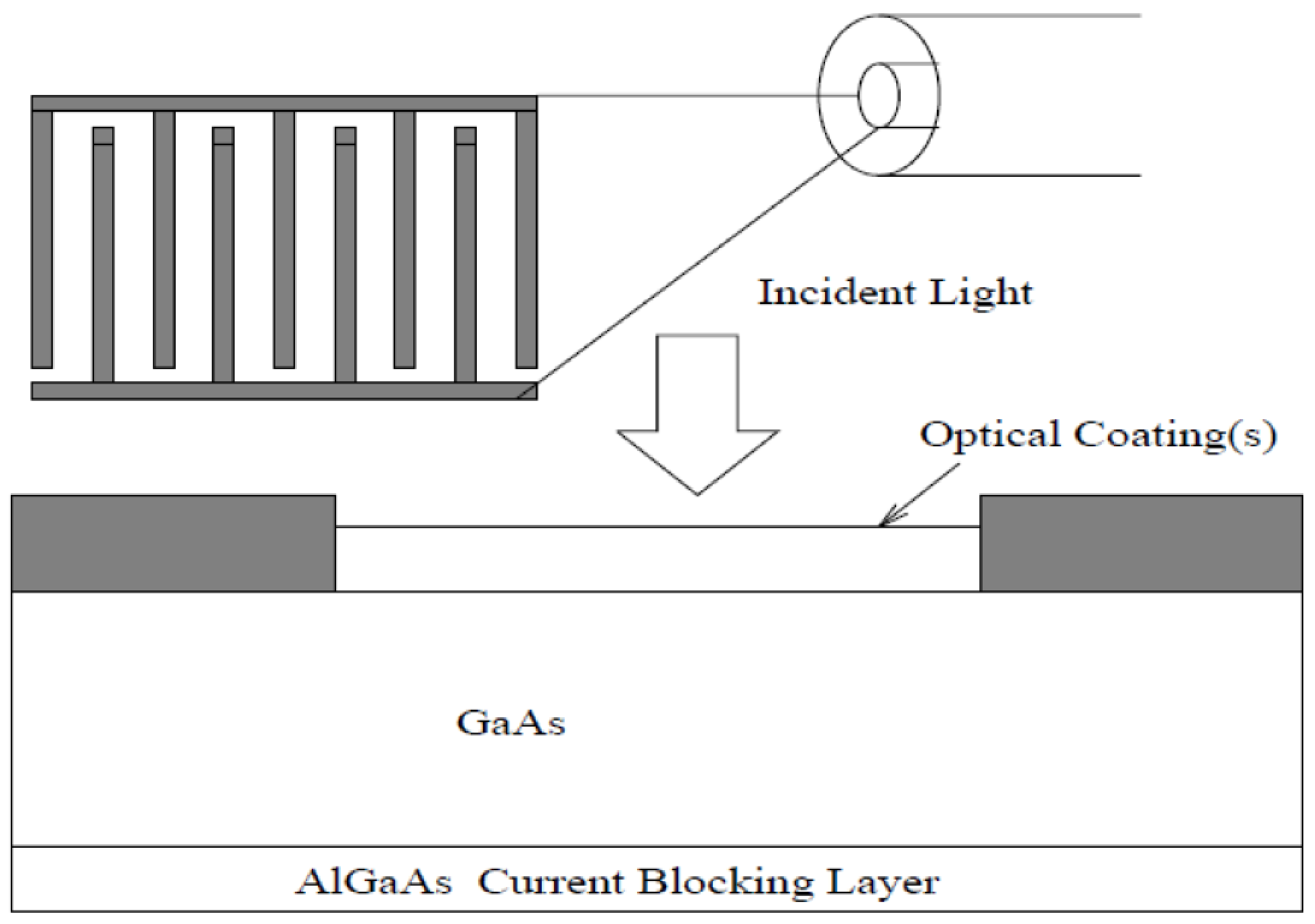

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MSM .layer file

Defining the device structure – msm.layer file

Simulation software by:

Crosslight Software Inc.

http://crosslight.com/

```
begin_layer
$
column column_num=1 w=0.5 mesh_num=4 r=0.8 &&
column column_num=2 w=1.5 mesh_num=19 r=-1.3 &&
xpoint_left=yes xpoint_right=yes
column column_num=3 w=0.5 mesh_num=4 r=1.2 &&
xpoint_left=yes
$
$ The lower current blocking layer.
$
layer_mater macro_name=algaas var1=0.3 column_num=1
layer_mater macro_name=algaas var1=0.3 column_num=2
layer_mater macro_name=algaas var1=0.3 column_num=3
layer d=0.15 n=4 r=1. &&
n_doping1=1.e21 n_doping2=1.e21 n_doping3=1.e21 &&
xp2=1
$
$ The main part of the GaAs MSM.
$
layer_mater macro_name=gaas column_num=1
layer_mater macro_name=gaas column_num=2
layer_mater macro_name=gaas column_num=3
layer d=0.5 n=8 r=0.8 &&
n_doping1=1.e21 n_doping2=1.e21 n_doping3=1.e21 &&
xp1=1 xp2=1
$
$ These are the two electrodes.
$
top_contact column_num=1 from=0 to=0.5 contact_num=1
top_contact column_num=3 from=0 to=0.5 contact_num=2
$
end_layer
```

Define three columns so that extra mesh lines can be allocated near the electrodes. For AaPSYS simulation Schottky contacts require extra mesh lines so that the barrier height can be accurtely defined.

MSM .sol file – part I

Defining the device structure – msm.sol file

Simulation software by:

Crosslight Software Inc.

http://crosslight.com/

```
$file:msm.sol
$***********
begin
load_mesh mesh_inf=msm.msh
$
$ Equilibrium solution.
$
newton_par damping_step=5. var_tol=1.e-9 res_tol=1.e-9 &&
equilibrium
$
$ Ramp up the DC bias to 5 volts.
$
newton_par damping_step=1. var_tol=1.e-4 res_tol=1.e-4 &&
max_iter=30 opt_iter=15 stop_iter=15 print_flag=3
scan var=voltage_1 value_to=-5. print_step=5. &&
init_step=0.2 min_step=1.e-5 max_step=1.0
$
$ Turn on the Gaussian optical pulse with
$ pulse width of 4 ps.
$
scan var_num=2 2_variables=(time light) &&
value_to=50.D-12 print_step=50.D-12 &&
init_step=1.D-14 min_step=1.d-18 max_step=1.D-12 &&
relation=gaussian gsn_dt=4.e-12
$
$ We wait some more time until the MSM settles down.
$
scan var=time value_to=300.D-12 print_step=300.D-12 &&
init_step=1.D-12 min_step=1.d-15 max_step=10.D-12
```

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MSM .sol file – part II

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```
$ **********incident light*****************
$
$ Define the incident light here. The profile is used
$ to block out the light for the area under the metal electrodes.
$
light_power incident_power=3.29e7 wavelength=0.82 &&
profile=(0.5, 2.0, 0.01, 0.01)
$
$ Put optical coatings on top of device, if you wish.
$ It may be used to optimize the optical interference inside
$ the MSM.
$
$optic_coating thickness=0.147 real_index=2.05 imag_index=0.
$
back_reflection real_refl=0. imag_refl=0.
output sol_outf=msm.out
$ *************************
$ Define the barrier potential for the Schottky contacts.
$
contact type=schottky barrier=-0.83 num=1
contact type=schottky barrier=-0.83 num=2
$
$ Include the doping and material description generated
$ by msm.layer.
$
include file=msm.doping
include file=msm.mater
$
$
$ Be sure to define the absorption for the GaAs layer. Otherwise
$ there will be no response from the detector
$
absorption value=1.1e6 mater=2
$
end
```

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End of Introduction part II