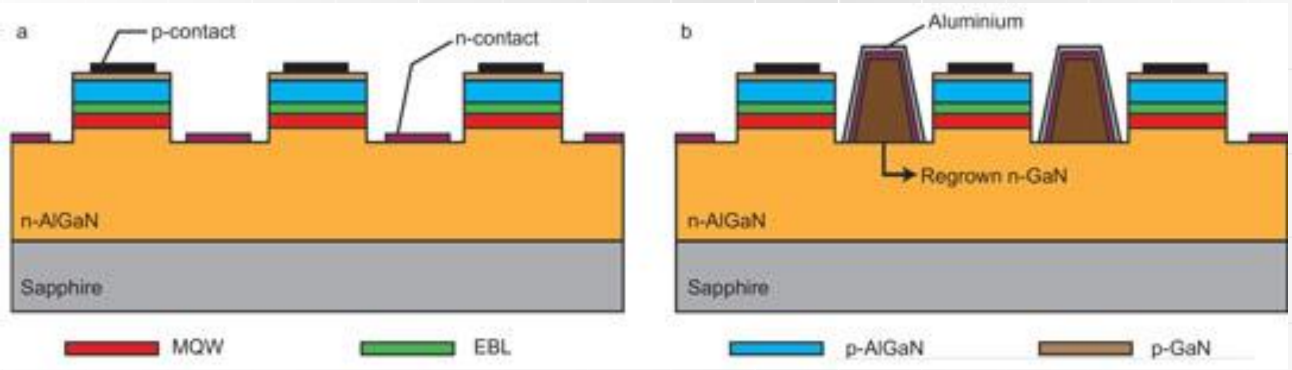
Elementy i układy optoelektroniczne



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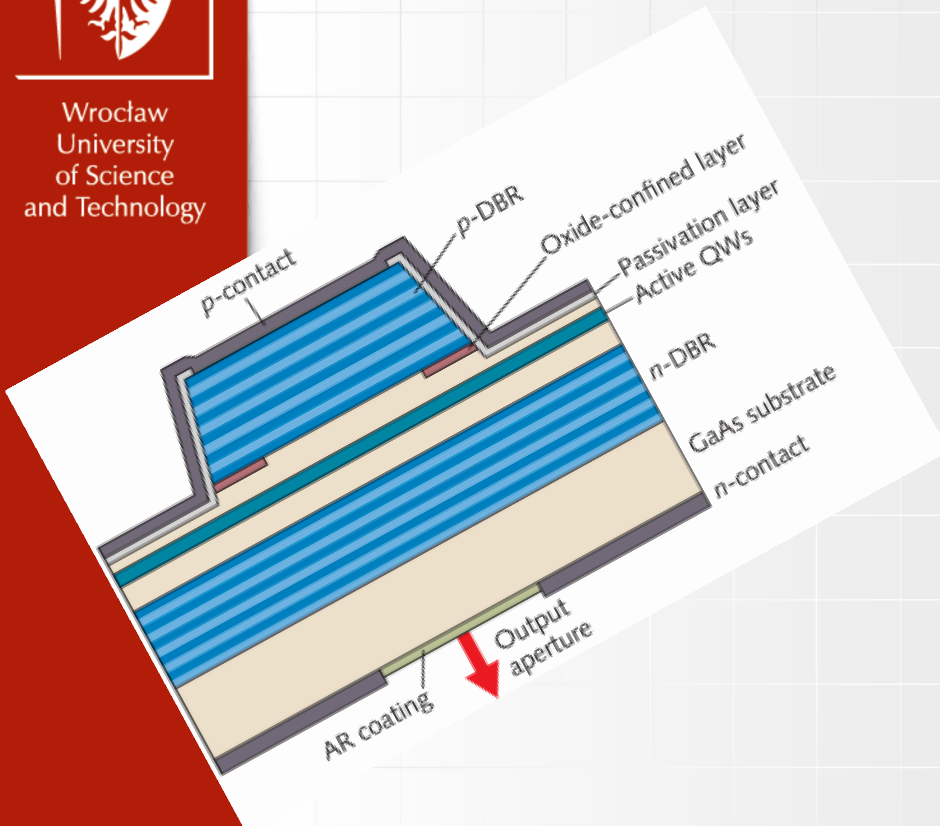
Elementy i układy optoelektroniczne



Wstęp

Simulation software by:

Crosslight Software Inc.

http://crosslight.com/

Dr inż. Damian Radziewicz

Wrocław 2019

HR EXCELLENCE IN RESEARCH

Wroclaw University of Science and Technology

Wprowadzenie

- Informacje o prowadzącym
- Informacje o projekcie
- Wprowadzenie do APSYS'a

Simulation software by:

Crosslight Software Inc.

http://crosslight.com/

Informacje o prowadzącym

Dr inż. Damian Radziewicz

Damian.Radziewicz@pwr.edu.pl

C-2: p. 306, p. 111

M-11: p 138 tel. 4949 (320 4949)

<u>Konsultacje:</u>

Poniedziałek: $9^{\underline{00}}$ – $11^{\underline{00}}$, M-11

Piątek: $11^{\underline{15}}$ – $13^{\underline{15}}$, M-11

Informacje o projekcie

Projekt	Terminy

Projekt

- APSYS
- Symulacja struktur testowych
- Symulacja struktur projektowych
- Przygotowanie raportów

Terminy

- I Raport

10-12-2019

- II Raport

28-01-2020

Przykład struktury modelowanej

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

APSYS informacje 1

APSYS definicja

APSYS is a general purpose 2D/3D modeling software program for semiconductor devices. Based on finite element analysis, it includes many advanced physical models such as hot carrier transport, heterojunction models and thermal analysis. APSYS offers a very flexible and simulation environment for modern semiconductor devices.

APSYS can be applied to the modeling and analysis of almost all devices except semiconductor lasers (which are simulated by other products **LASTIP** and **PICS3D**).

These include the following devices based on silicon and compound materials.

- 1. Silicon MOSFET, bipolar transistors and CCD.
- 2. HBT based on SiGe, AlGaAs and InGaAsP.
- 3. GaAs MESFET and Photodectors.
- 4. GaN HEMT.
- 5. Light Emitting Diodes (LED).
- 6. Electro-absorption modulators.
- 7. Organic semiconductor devices (OLED).
- 8. Compound, thin film and multi-junction Solar Cells.

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APSYS informacje 2

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APSYS can solve self-consistently the hydrodynamic equations, the heat transfer equations as well as the conventional drift-diffusion equations. Data generated by APSYS include the following:

- 1) Current versus voltage (I-V) characteristics.
- 2) 2D potential, electric field and current distributions.
- 3) 2D distributions of electron and hole concentrations.
- 4) 2D distributions of hot carrier temperatures in the hydrodynamic model.
- 5) 2D distributions of lattice temperature for the heat transfer model.
- 6) Band diagrams under various bias conditions.
- 7) Results of AC small signal analysis for any frequency range. Extraction of 2-port AC parameters such S- and Y- parameters.
- 8) Quantum well subband structure with valence mixing model for quantum devices.
- 9) 2D distributions of occupancy and concentration of deep level traps in a semiconductor.
- 10) 2D optical field distribution for photonic devices such as photodetectors.
- 11) Spontaneous emission spectrum as a function of current for LED's.
- 12) All of the above as a function of time (transient model).
- 13) All of the above at different environment temperatures.

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APSYS informacje 3

- .geo - The main input file that describe the full details of the device geometry and the initial mesh allocation.
- .sol - The main input file that defines the material properties and controls the bias and other conditions of main equation solver.
- .layer - An important auxiliary input file that uses the layer structure description to generate the .geo, .doping, .mater and .mplt files,
- **.doping** which contains doping information that is to be included in the .sol file.
- **.mater** which contains material information that is to be included in the .sol file.
- **.mplt** can be used to plot the mesh generated from .geo file.
- **.gain** file is another important auxiliary input file that can be used to preview the optical gain spectrum, spontaneous emission rate spectrum, quantum well subbands, and other critical physical properties. This may be used by the user to do some preliminary estimate before the full simulation is performed.
- .out files may appear as .out 01, .out 02, etc.. These are numerical output data from the main equation solver. They can be used by the .plt program to be plotted. These output files are not meant to be understood by the user.
- .std files may appear as .std 01, .std 02, etc.. These are another form of numerical output data from the main equation solver. They can be used by the CrosslightView program to be displayed in 3D color graphics. These output files can be understood by the user should there were such a need.
- **.plt** file is used to plot the data in .out output files. APSYS calls the public domain software GNUPLOT to display the graphics in various computer platforms and printers.

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APSYS informacje 4

Podstawowa procedura:

1. Uruchomić plik „*.layer”, który wygeneruje plik „*.geo”.
2. Uruchomić plik „*.geo”, który wygeneruje „mesh”.
3. Uruchomić główny program z wejściowym plikiem „*.sol”.
4. (Opcjonalnie) Wyniki mogą być wykreślone przez CrosslightView. Można to wykonać przez kliknięcie pliku *.std w SimuCenter albo w menu: “Action → View Results → CrosslightView”. Program można również niezależnie uruchomić z menu systemu.

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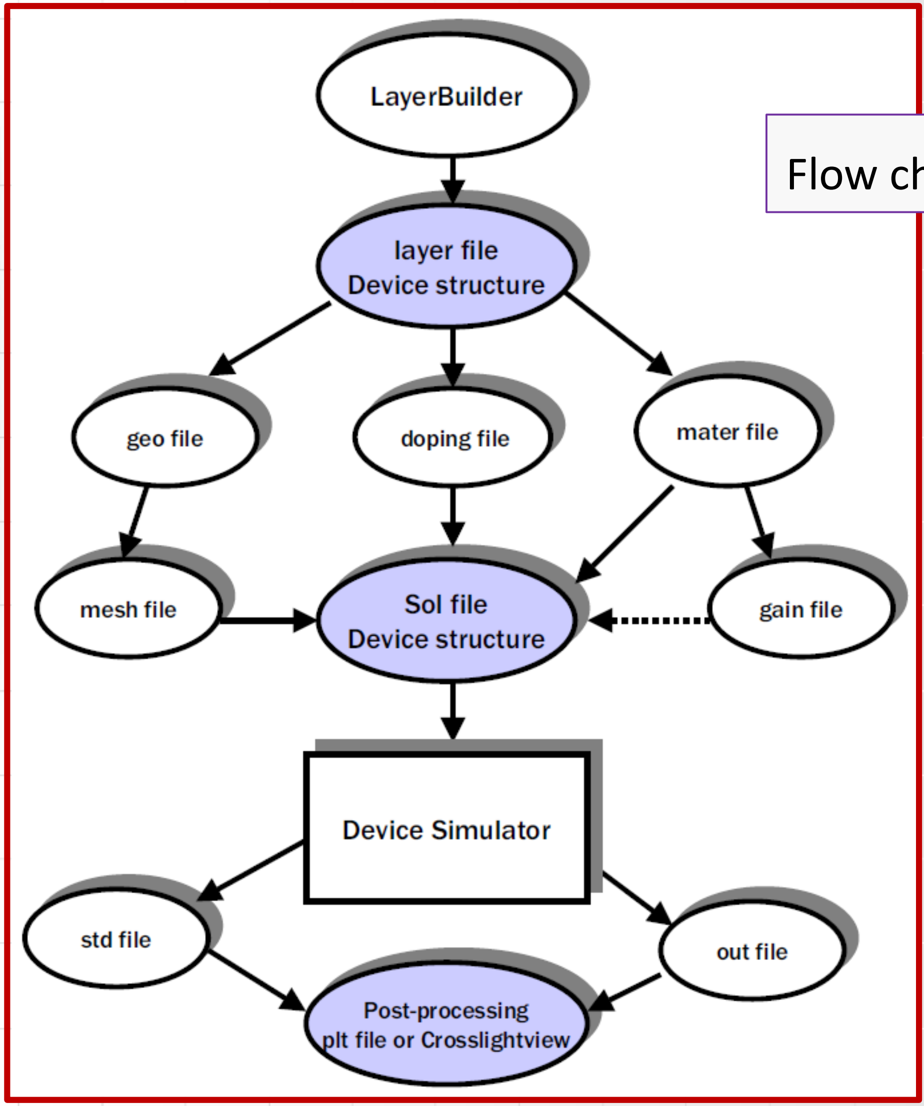
APSYS informacje 5

Flow chart symulatora przyrządów Crosslight



Tylko niebieskie pliki muszą być wprowadzone przez użytkownika.

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APSYS informacje 6

Definicja struktury przyrządu – przekrój

Simulation software by:

Crosslight Software Inc.

http://crosslight.com/

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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Simulation software by:

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APSYS informacje 6

Definicja struktury przyrządu – plik test1.layer

```
$file:test1.layer
begin_layer
column column_num=1 w= 0.150000E+01 mesh_num=2 r=1.
bottom_contact column_num=1 from=0 to= 0.150000E+01 &&
 contact_num=1 contact_type=ohmic
$
layer_mater macro_name=algaas &&
 var_symbol1=x var1= 0.500000E+00 &&
 column_num=1
layer d= 0.100000E+01 n= 13 &&
 n_doping1= 0.100000E+25 &&
 r= 0.800000E+00
$
layer_mater macro_name=algaas &&
 var_symbol1=x var1= 0.000000E+00 &&
 active_macro=AlGaAs &&
 avar_symbol1=xw avar1= 0.000000E+00 &&
 column_num=1
layer d= 0.200000E+00 n= 5 &&
 shift_center= -0.111111E-01 &&
 r= -0.120000E+01
$
layer_mater macro_name=algaas &&
 var_symbol1=x var1= 0.500000E+00 &&
 column_num=1
layer d= 0.100000E+01 n= 11 &&
 p_doping1= 0.100000E+25 &&
 r= 0.120000E+01
$
top_contact column_num=1 from=0 to= 0.150000E+01 &&
 contact_num=2 contact_type=ohmic
end_layer
```

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Simulation software by:

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APSYS informacje 6

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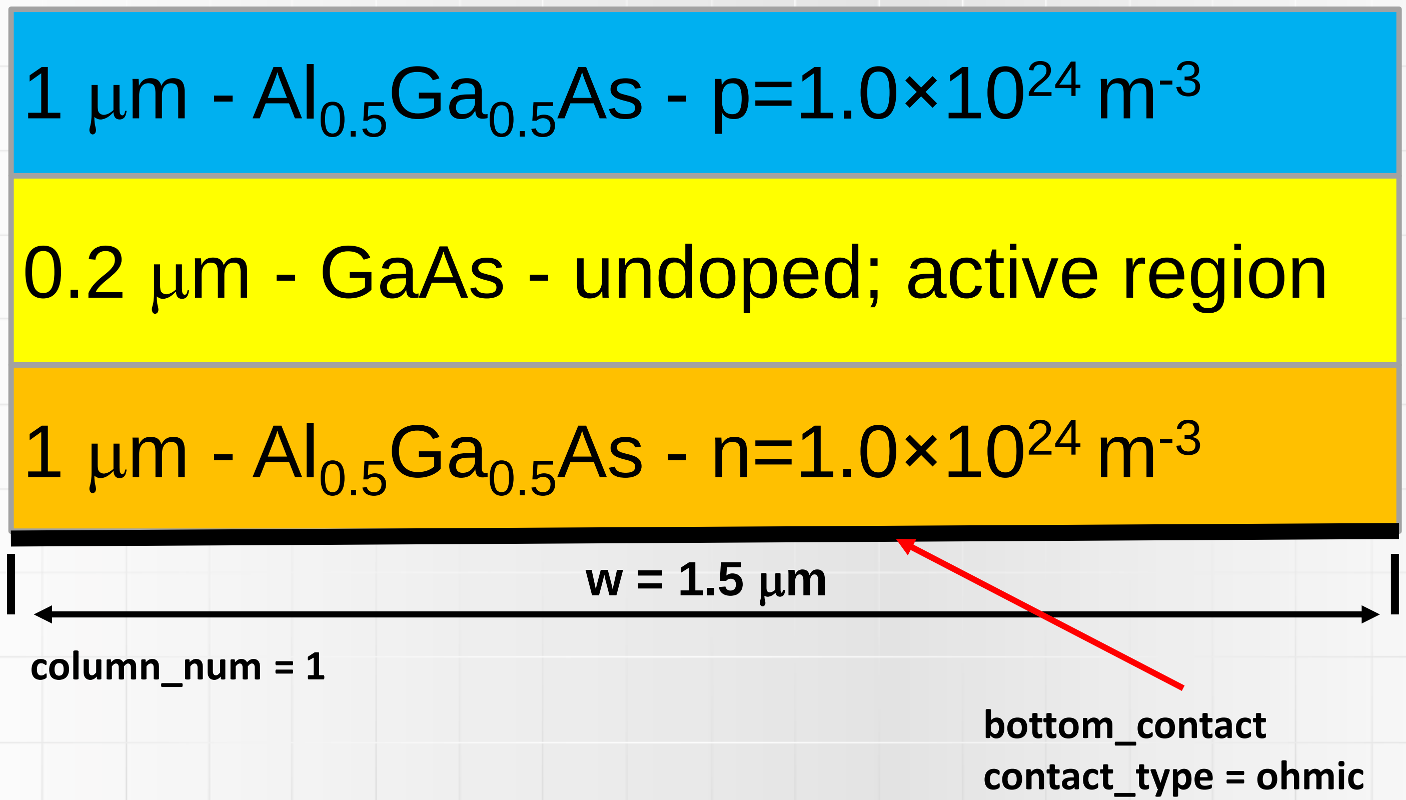
```



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APSYS informacje 6

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layer_mater macro_name=algaas &&
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 column_num=1
layer d= 0.100000E+01 n= 13 &&
 n_doping1= 0.100000E+25 &&
 r= 0.800000E+00
```

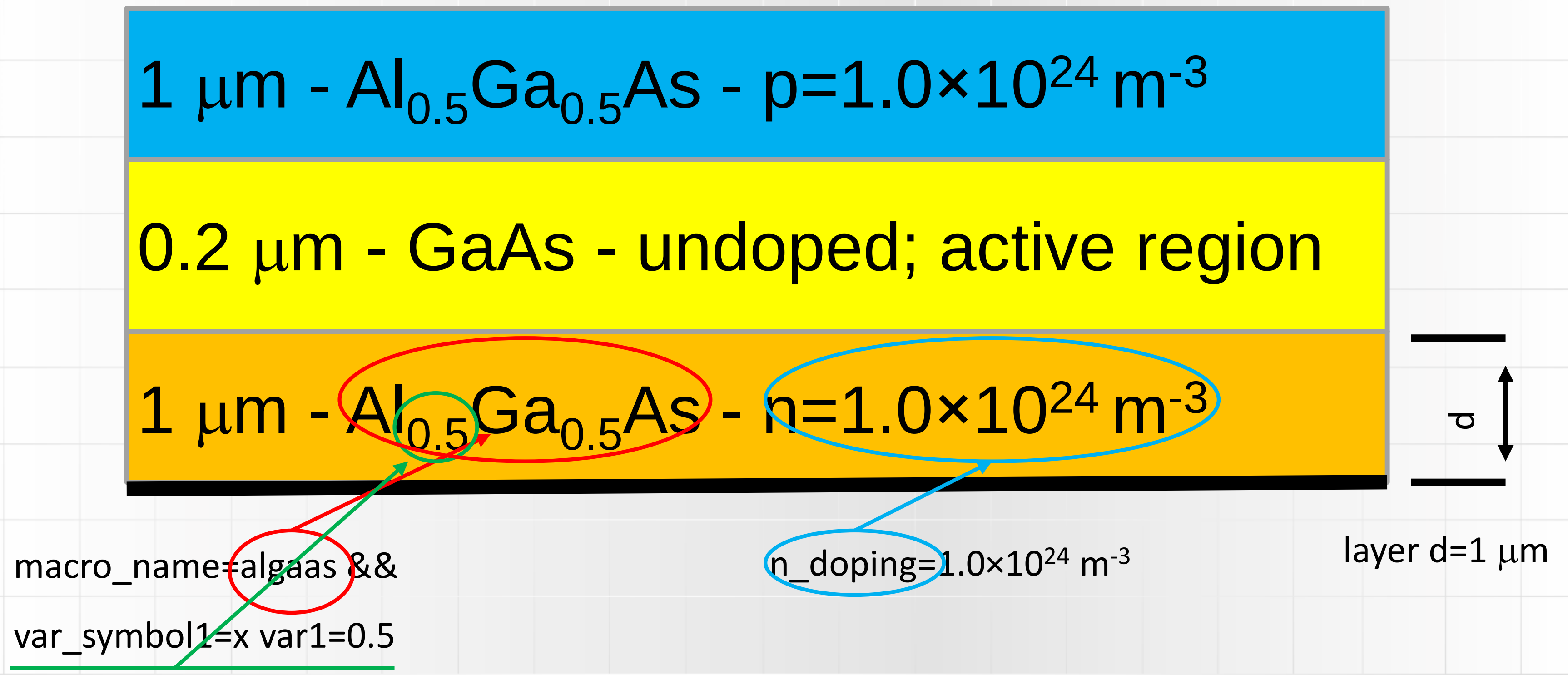

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Simulation software by:

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APSYS informacje 6

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  active_macro=AlGaAs &&
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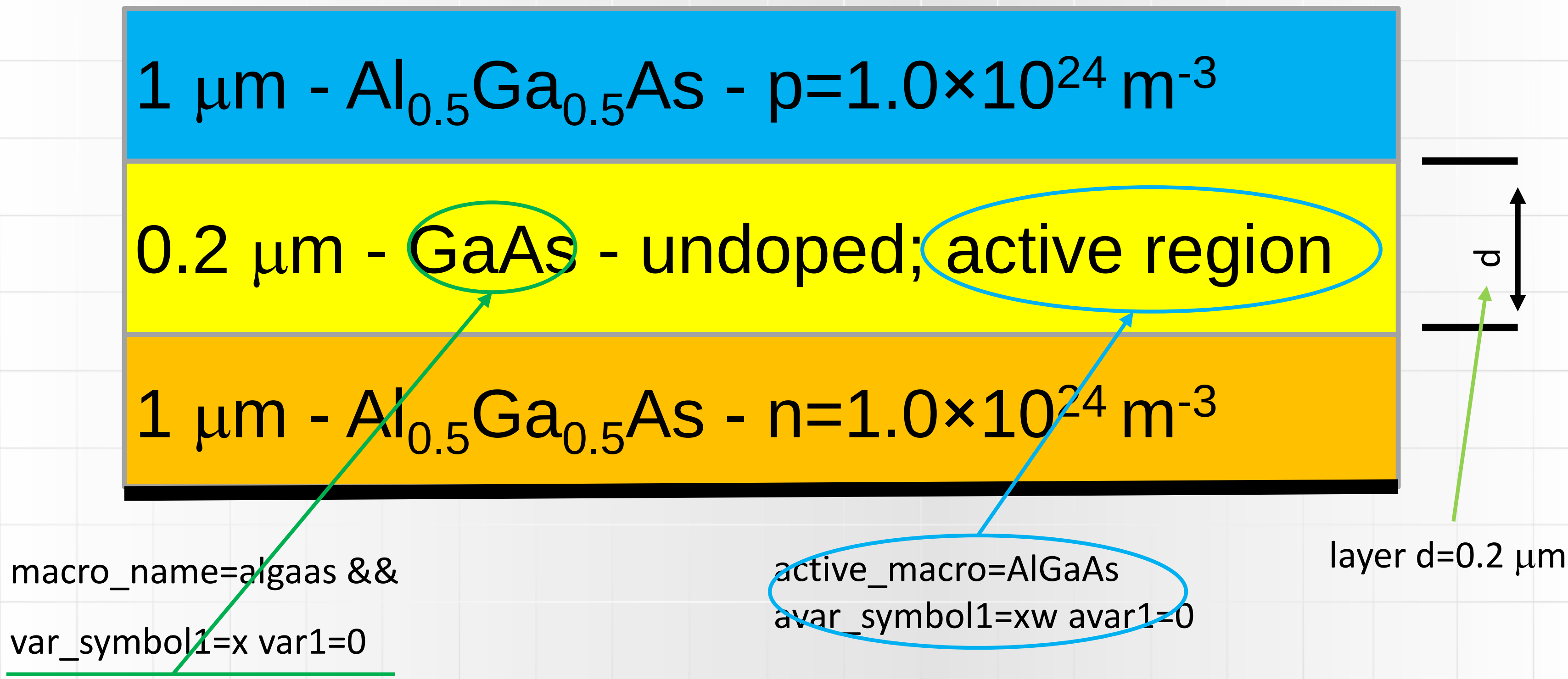
  column_num=1
layer d= 0.200000E+00 n= 5 &&
  shift_center= -0.111111E-01 &&
  r= -0.120000E+01
```



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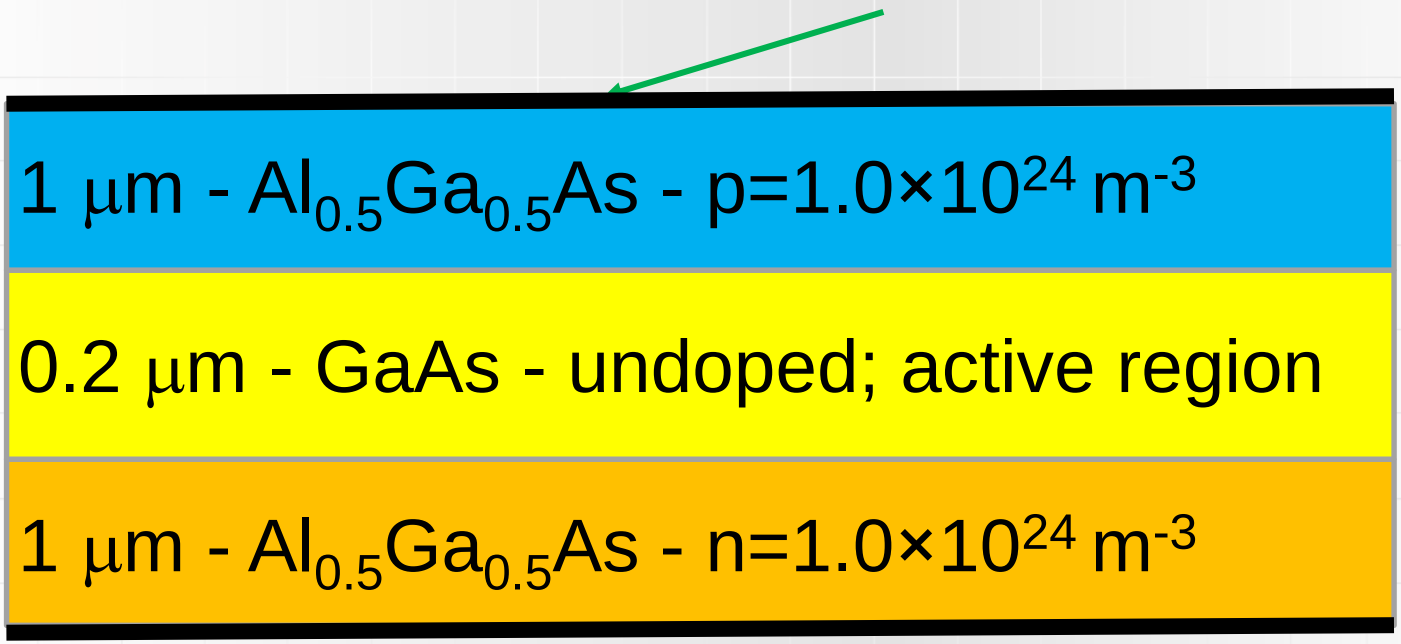
APSYS informacje 6

Definicja struktury przyrządu – plik test1.layer

top_contact column_num=1 from=0 to= 0.150000E+01 &&
contact_num=2 contact_type=ohmic

top_contact
contact_type = ohmic



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 contact_num=2 contact_type=ohmic
end_layer
```

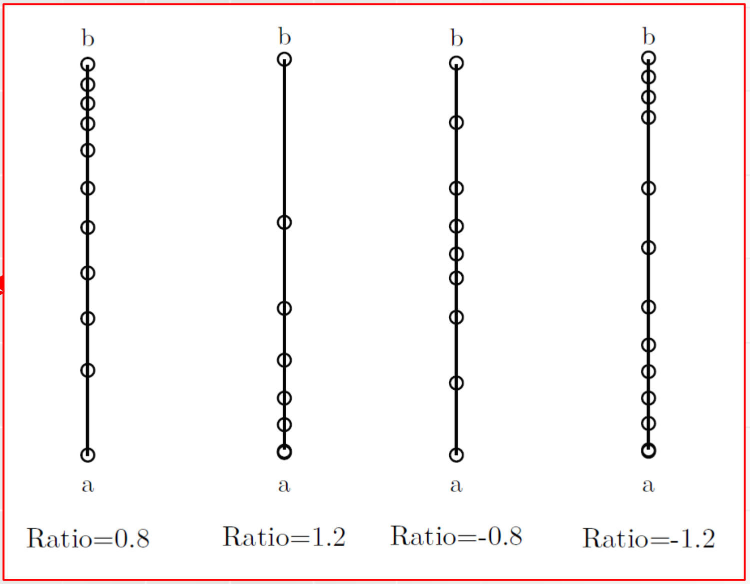

Effects of different ratio on putting mesh points on an edge (a b).

mesh lines dla kolumn.

mesh lines dla layer.

Koniec wstępu