Step by step with ATLAS Silvaco

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Getting Started with Atlas

Ali Abdolahzadeh Ziabari

Atlas is a physically-based **two** and **three dimensional** device simulator. It predicts the **electrical behavior** of specified semiconductor structures and provides insight into the internal physical mechanisms associated with device operation.

1-Running Atlas inside Deckbuild

Each Atlas run inside DeckBuild should start with the line:

```
go atlas
```

2-The Order of Atlas Commands

Group	*Statements*
1. Structure Specification	MESH REGION ELECTRODE DOPING
2. Material Models Specification	MATERIAL MODELS CONTACT INTERFACE
3. Numerical Method Selection	METHOD
4. Solution Specification	LOG SOLVE LOAD SAVE
5. Results Analysis	EXTRACT TONYPLOT

3- Using The Command Language to Define a Structure

You must first define a mesh. The first statement **must be**:

```
MESH SPACE.MULT=<VALUE>
```

This is followed by a series of `X.MESH` and `Y.MESH` statements.

```
X.MESH LOCATION=<VALUE> SPACING=<VALUE>
.
Y.MESH LOCATION=<VALUE> SPACING=<VALUE>

.
```

The `SPACE.MULT` parameter value is used as a scaling factor for the mesh created by the `X.MESH` and `Y.MESH` statements. The default value is 1. Values greater than 1 will create a globally coarser mesh for fast simulation. Values less than 1 will create a globally finer mesh for increased accuracy.

EXAMPLE: a simple mesh

```
go atlas

mesh space.mult=1

x.m l=-1 s=0.01
x.m l=0 s=0.05
x.m l=1 s=0.01

y.m l=0 s=1
y.m l=2 s=0.02

save outf=simple.str
tonyplot simple.str
```

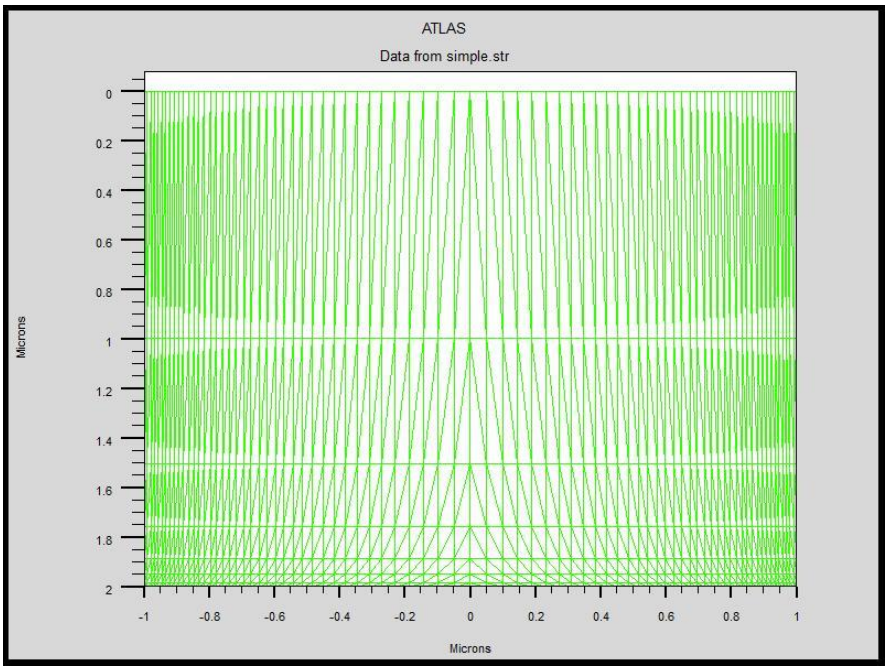
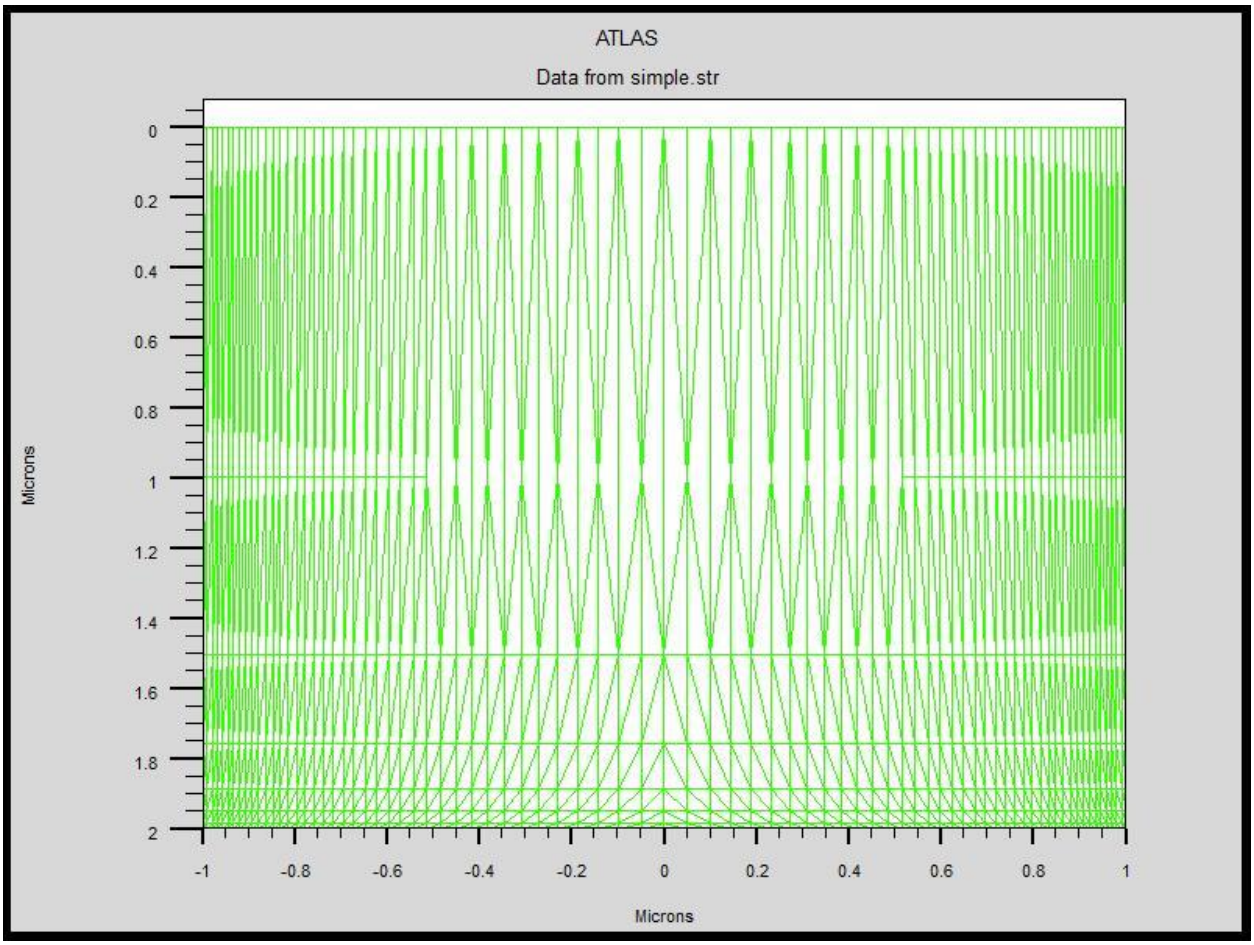


Fig.1. A simple structure by Atlas.

After an initial mesh has been defined, you can remove grid lines in specified regions. This is typically done in regions of the device where a coarse grid is expected to be sufficient such as the substrate. The removal of grid lines is accomplished using the **ELIMINATE** statement. The **ELIMINATE** statement removes every second mesh line in the specified direction from within a specified rectangle.

EXAMPLE:

```
go atlas

mesh space.mult=1

x.m l=-1 s=0.01
x.m l=0 s=0.05
x.m l=1 s=0.01

y.m l=0 s=1
y.m l=2 s=0.02

eliminate columns x.min=-0.5 x.max=0.5 y.min=0 y.max=1

save outf=simple.str
tonyplot simple.str
```

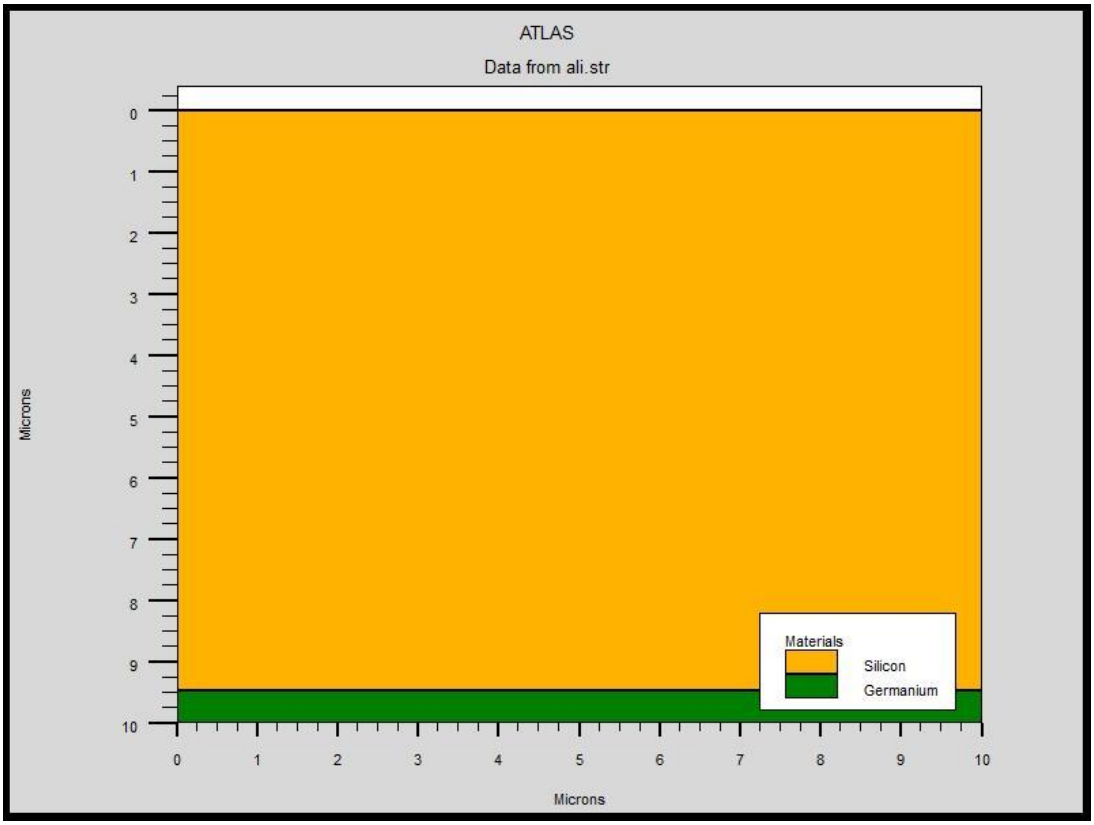

ATLAS
Data from simple.str
Microns
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Microns

4-Specifying Regions and Materials

```
REGION number=<integer> <material_type> <position parameters>
```

Example:

```
go atlas

mesh space.mult=1.0

x.mesh loc=0.0  spacing=2.5
x.mesh loc=10.0 spacing=2.5

y.mesh loc=0.0   spacing=0.05
y.mesh loc=5.0   spacing=0.2
y.mesh loc=10  spacing=0.05

region num=1 material=Silicon  y.max=9.5
region num=2 material=Ge       y.min=9.5 y.max=10

save outf=ali.str
tonyplot ali.str
```



5- Specifying Electrodes

Once you have specified the regions and materials, define at least one electrode that contacts a semiconductor material. This is done with the ELECTRODE statement:

```
ELECTRODE NAME=<electrode name> <position_parameters>
```

You can **specify** up to **50 electrodes**.

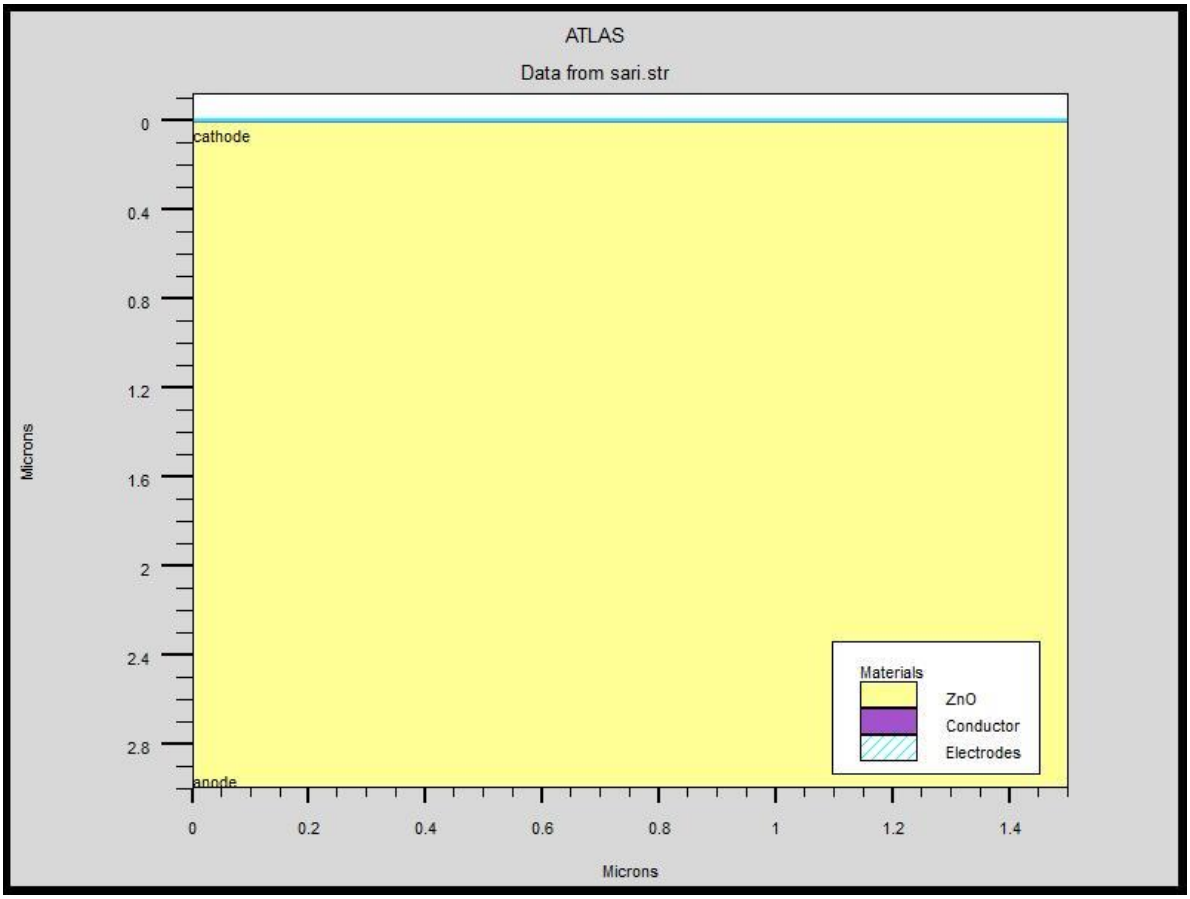
Shortcuts: If no Y coordinate parameters are specified, the electrode is assumed to be located on the top of the structure. You also can use the RIGHT, LEFT, TOP, and BOTTOM parameters to define the location. For **example**:

```
ELECTRODE NAME=SOURCE LEFT LENGTH=0.5
```

specifies the source electrode starts at the top left corner of the structure and extends to the right for the distance LENGTH.

Example

```
go atlas

mesh space.mult=1

x.m l=0 s=0.5
x.m l=1.5 s=0.2

y.m l=0 s=0.2
y.m l=3 s=0.1

region num=1 mat=zno y.min=0 y.max=3

electrode name=cathode top length=2
electrode name=anode bottom  length=2

save outf=sari.str
tonyplot sari.str
```


ATLAS
Data from sari.str
cathode
anode
Materials
ZnO
Conductor
Electrodes
Microns
0
0.4
0.8
1.2
1.6
2
2.4
2.8
0.2
0.6
1
1.4

6- Specifying Doping

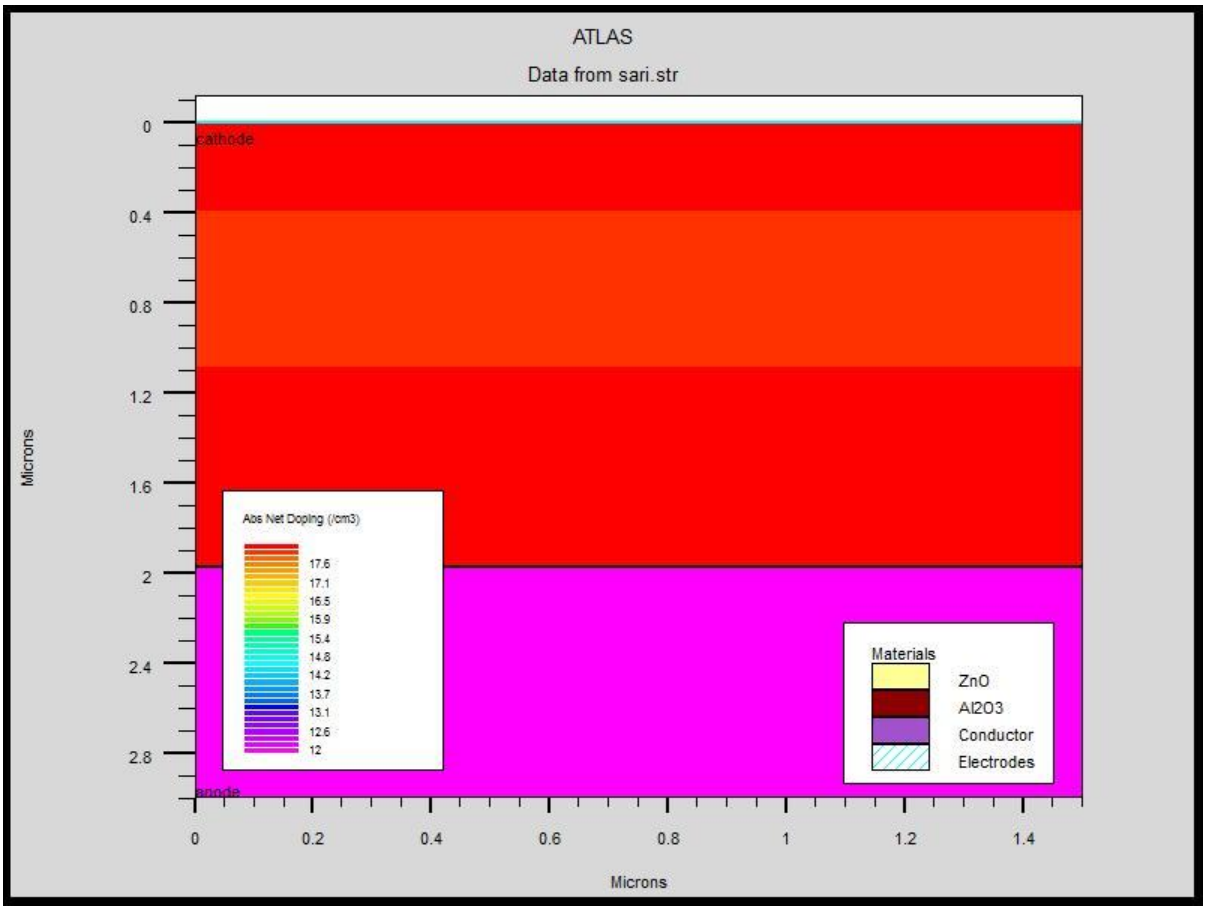
You specify the doping using the DOPING statement. For example:

```
DOPING <distribution_type> <dopant_type> <position_parameters>
```

Analytical doping profiles can have **uniform**, **Gaussian**, or **complementary** error function forms. The parameters defining the analytical distribution are specified in the DOPING statement.

Example

```
go atlas

mesh space.mult=1

x.m l=0 s=0.5
x.m l=1.5 s=0.2

y.m l=0 s=0.2
y.m l=3 s=0.1

region num=1 mat=zno y.min=0 y.max=2
region num=2 mat=al2o3 y.min=2

electrode name=cathode top length=2
electrode name=anode bottom length=2

doping uniform concentration=1e18 n.type region=1
doping gaussian concentration=1e16 characteristic=0.05 p.type x.left=0
x.right=1.5 peak=0.75

save outf=sari.str
tonyplot sari.str
```


ATLAS
Data from sari.str
cathode
anode
Microns
Microns
0
0.4
0.8
1.2
1.6
2
2.4
2.8
0.2
0.6
1
1.4
Abs Net Doping (/cm3)
17.6
17.1
16.5
15.9
15.4
14.8
14.2
13.7
13.1
12.6
12
Materials
ZnO
Al2O3
Conductor
Electrodes

7- Auto-meshing

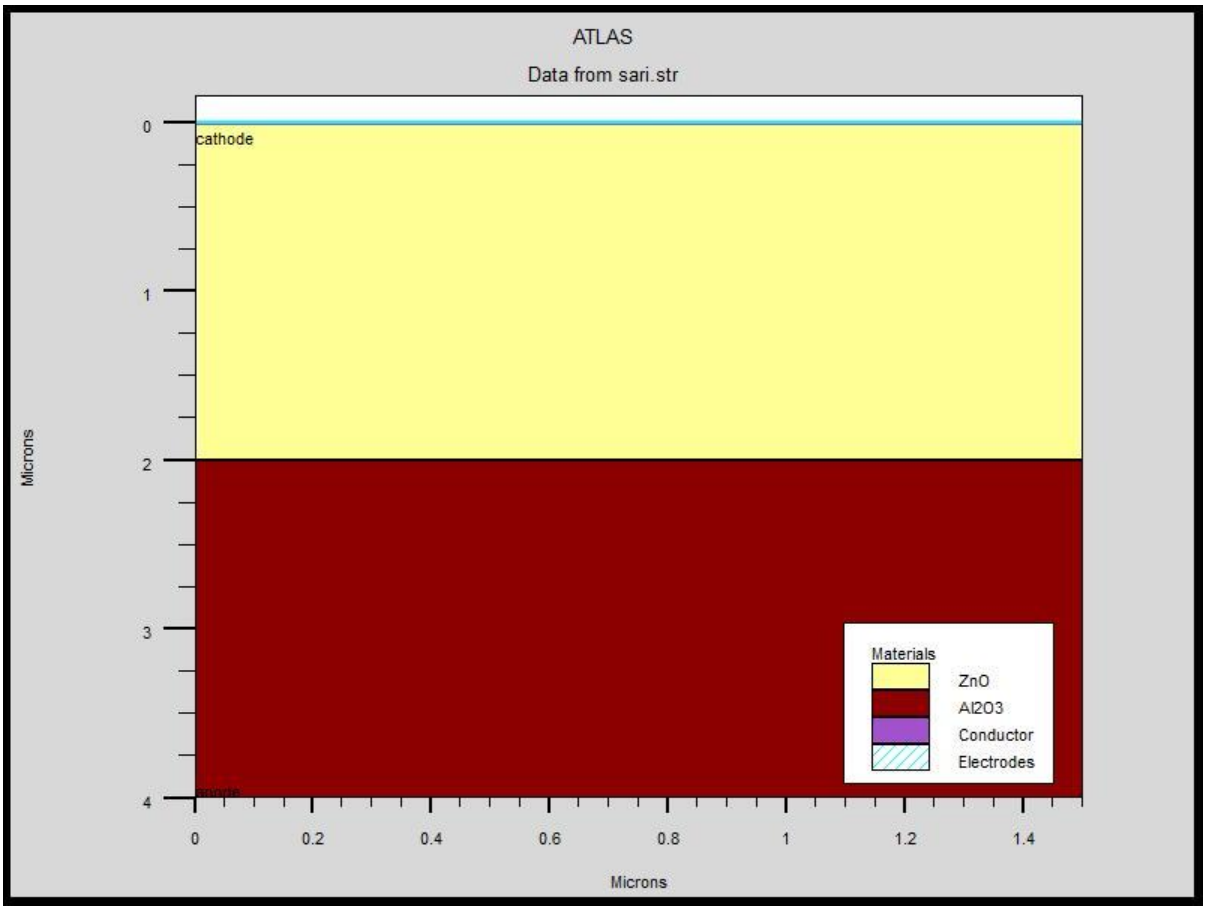
Statement:

```
MESH AUTO
X.M L=-1.0 S=0.1
X.M L=1.0 S=0.1
```

These statements are similar to the ones used in the standard method. There are, however, two key differences. The first difference is the inclusion of the AUTO parameter in the MESH statement. The second and more important difference is that we will not specify any Y.MESH statements. This is because the locations of Y mesh lines will be automatically determined by the parameters of the REGION statements.

Example

```
go atlas

mesh auto

x.m l=0 s=0.5
x.m l=1.5 s=0.2


region num=1 mat=zno y.min=0 y.max=2
region num=2 mat=al2o3 y.min=2 y.max=4

electrode name=cathode top length=2
electrode name=anode bottom length=2

doping uniform concentration=1e18 n.type region=1
doping gaussian concentration=1e16 characteristic=0.05 p.type x.left=0
x.right=1.5 peak=0.75 region=2

save outf=sari.str
tonyplot sari.str
```


ATLAS
Data from sari.str
cathode
anode
Microns
0
1
2
3
4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Microns
Materials
ZnO
Al2O3
Conductor
Electrodes

8- Donor, acceptor, x.composition, y.composition, NY and SY

Composition and doping are being specified in the REGION statement. This is the case for the DONOR, ACCEPTOR, X.COMPOSITION, and Y.COMPOSITION parameters in the REGION statement that specify uniform doping or composition or both over the specified region.
TOP, BOTTOM, THICKNESS, and NY parameters are used to describe the relative locations and thicknesses of the layers as well as the locations of the Y mesh lines.

The NY parameter describes how many Y mesh lines are contained in the region so that the Y mesh lines are evenly spaced over the region. You can use the SY parameter instead of NY to specify the spacing in microns between Y mesh lines in the region. Make sure the value of SY does not exceed the value of THICKNESS. Generally, the relationship between SY, NY and THICKNESS can be expressed by the following:

```
SY = THICKNESS/NY
```