Integrated Systems Engineering
Development, Modeling, and Optimization of Microelectronic Processes, Devices, Circuits, and Systems

MDRAW NMOS exercise example

(NMOS MDRAW)

March, 2004

What is MDRAW

- MDRAW is the ISE 2D structure, doping and mesh editor.
- MDRAW is a front end to the ISE meshing engine MESH.
- With MDRAW you create device geometries by simply drawing them.
- With MDRAW you define analytic doping profiles interactively.
- With MDRAW you define meshing strategies interactively.
- With MDRAW you can edit and re-mesh device structures from the process simulation.

MDRAW Basics

- **Input Decks**
  1. MDRAW stores the device structure information in two separate files. The geometrical information is stored in a boundary file which has a name *[basename]*.bnd.
  2. The information about doping profiles and meshing strategies is stored in a command file which has a name *[basename]*.cmd.
- **Output Files**
  - The final structure files that are loaded into the device simulator DESSIS are the grid file with a name *[basename]*.grd and the data file with a name *[basename]*.dat.
  - The grid file contains the information about all the verticies (nodes) in the structure, their connectivity and what region and material they belong to.
  - The data file contains the information about all the data sets, e.g., doping profiles, which are defined on those nodes.

MDRAW Basics

- **Launching MDRAW**
  - Launch MDRAW from a command prompt with:

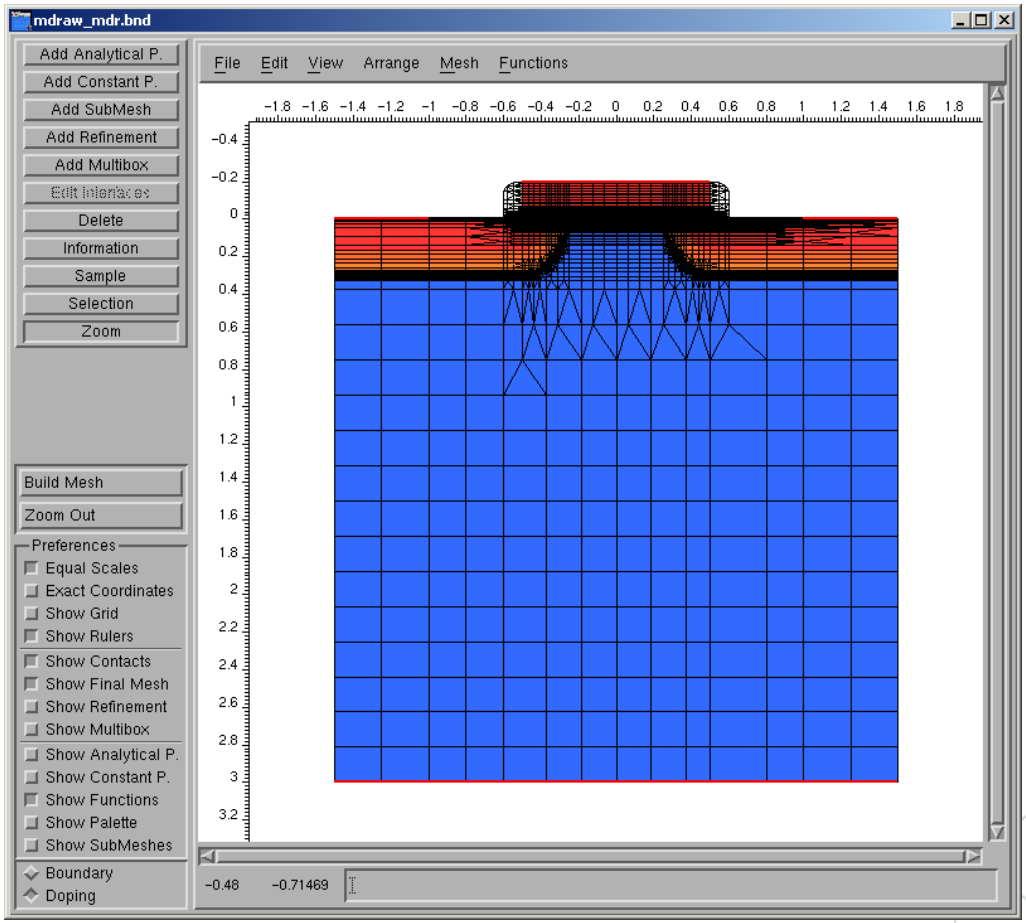
    > mdraw

- **Launching MDRAW with an existing structure**
  - Launch MDRAW from the command prompt with:

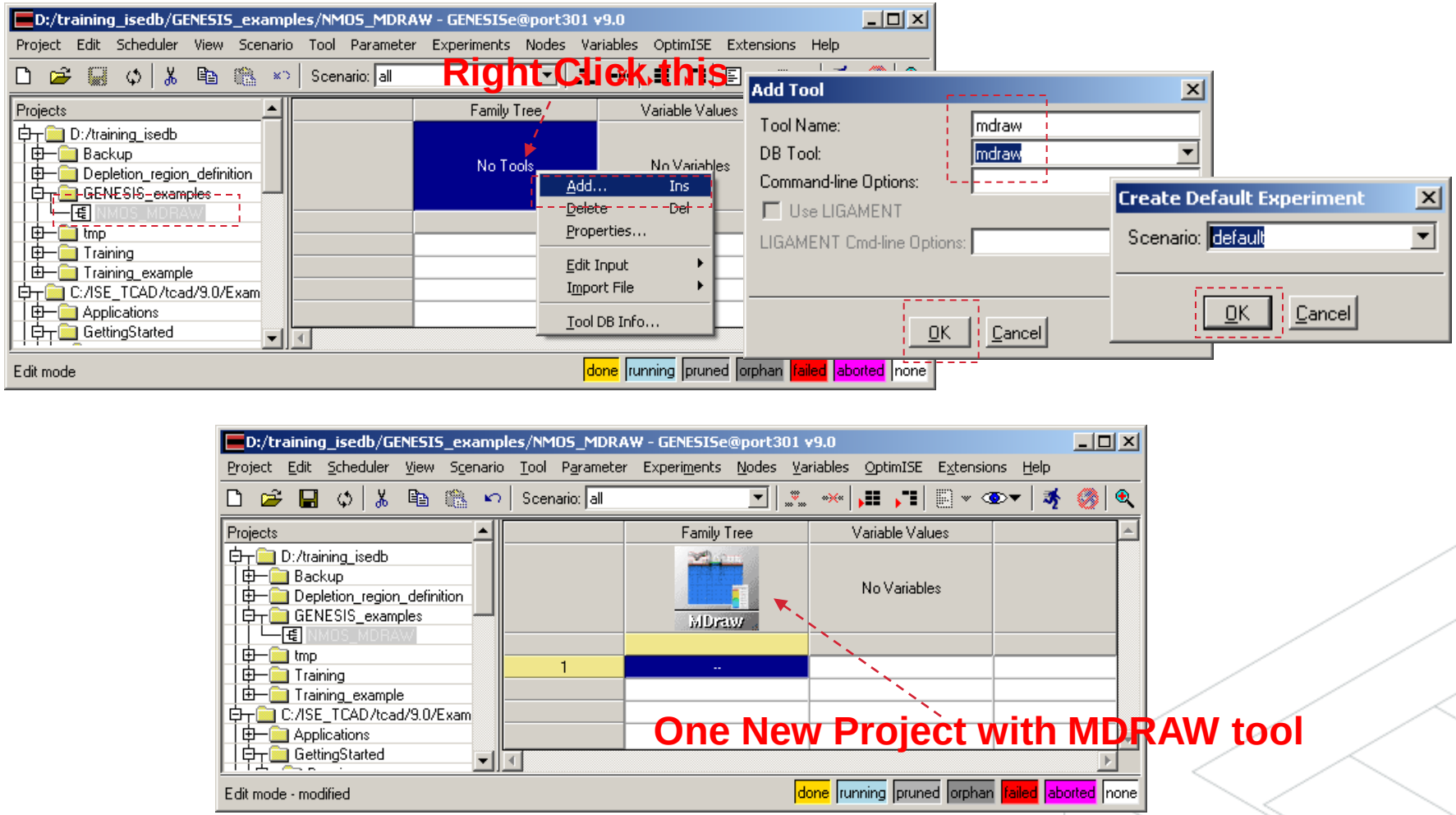
    > mdraw *[basename]*

TARGET

- Use Mdraw to define one 100A NMOS device withtout using DIOS or Floops.

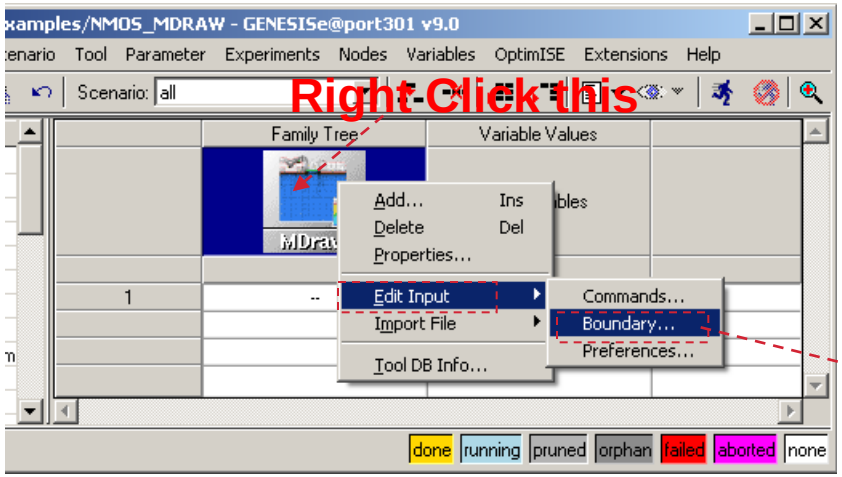


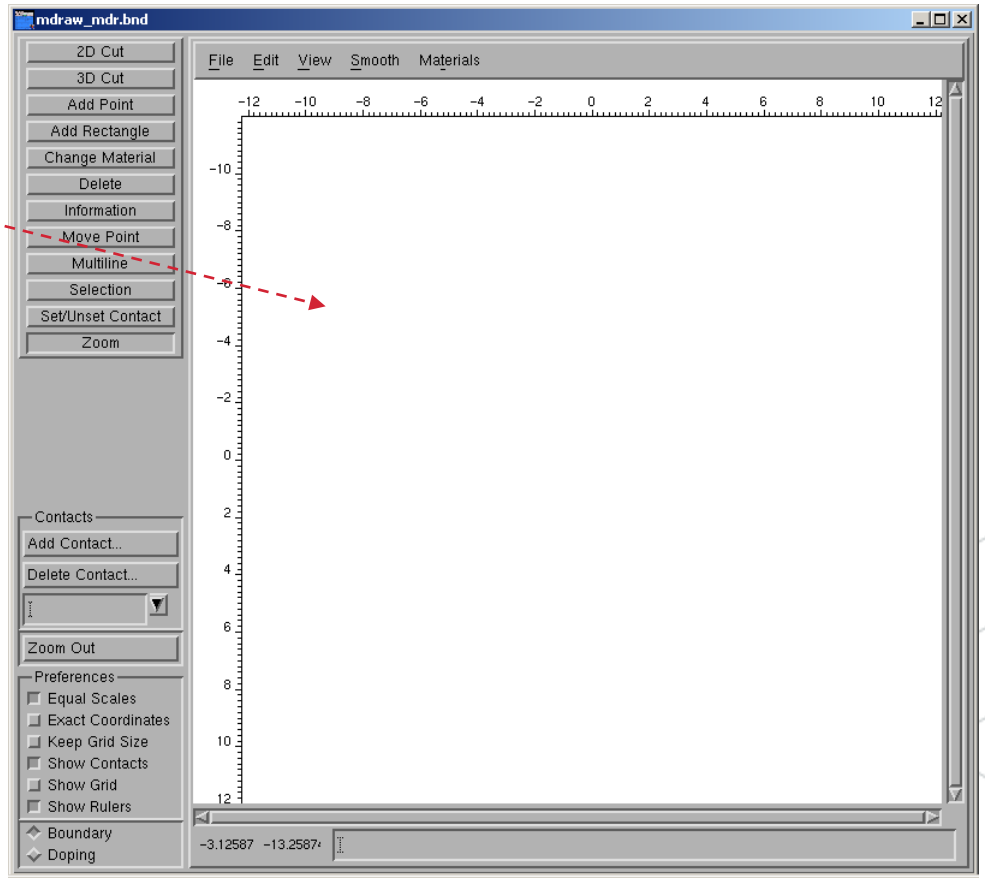
Open New Project : NMOS_MDRAW



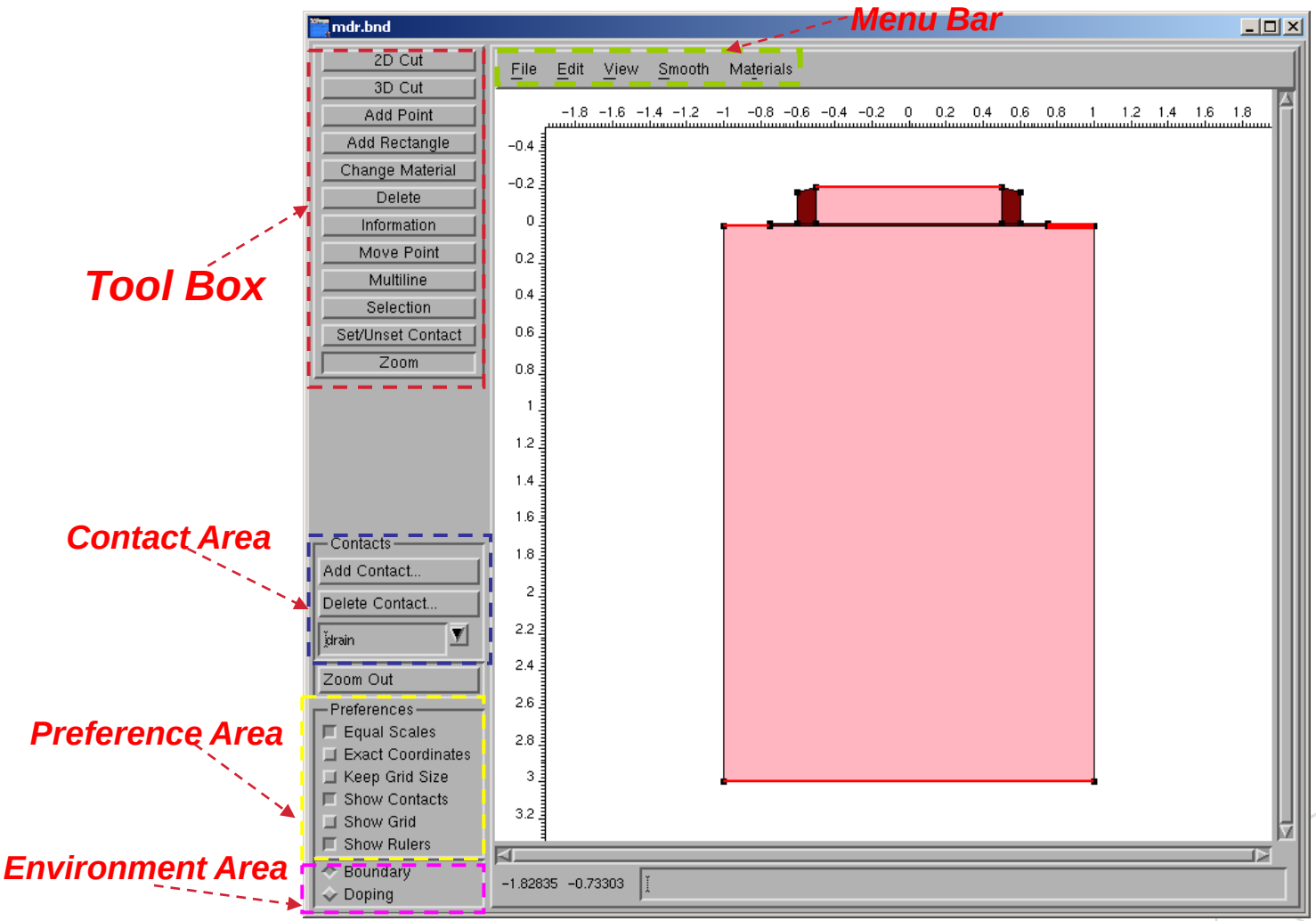
MDRAW Boundary Editor

Edit Mdraw Boundary



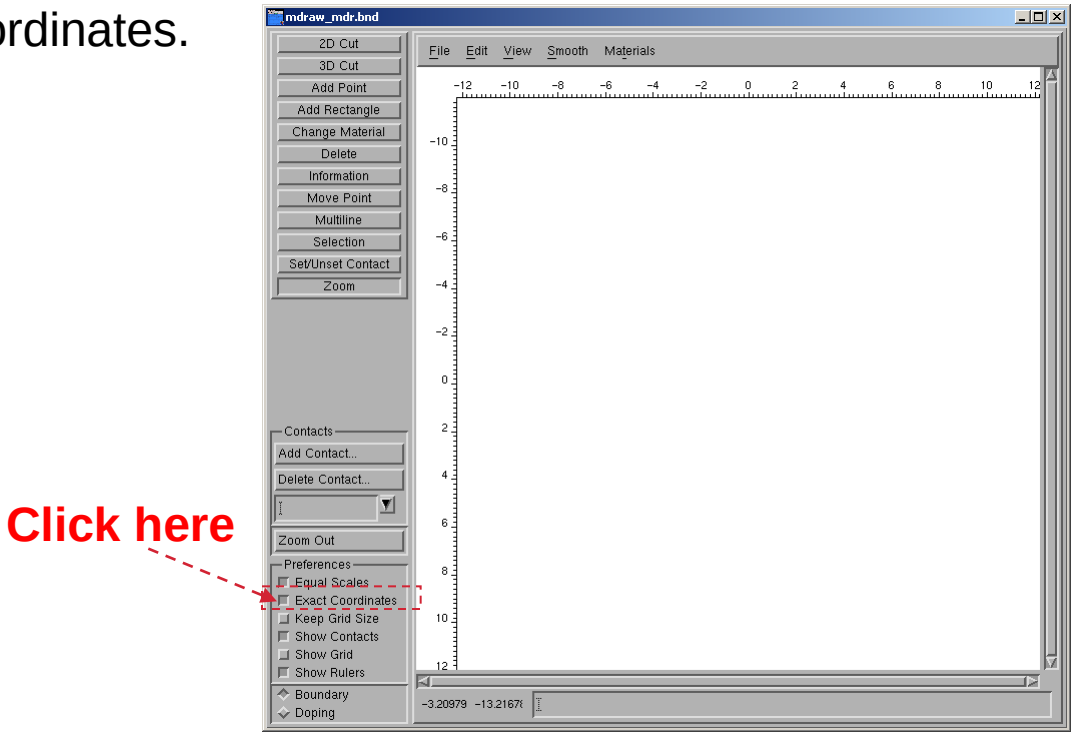


Mdraw: The Boundary Editor Interface



Exact Coordinate Mode

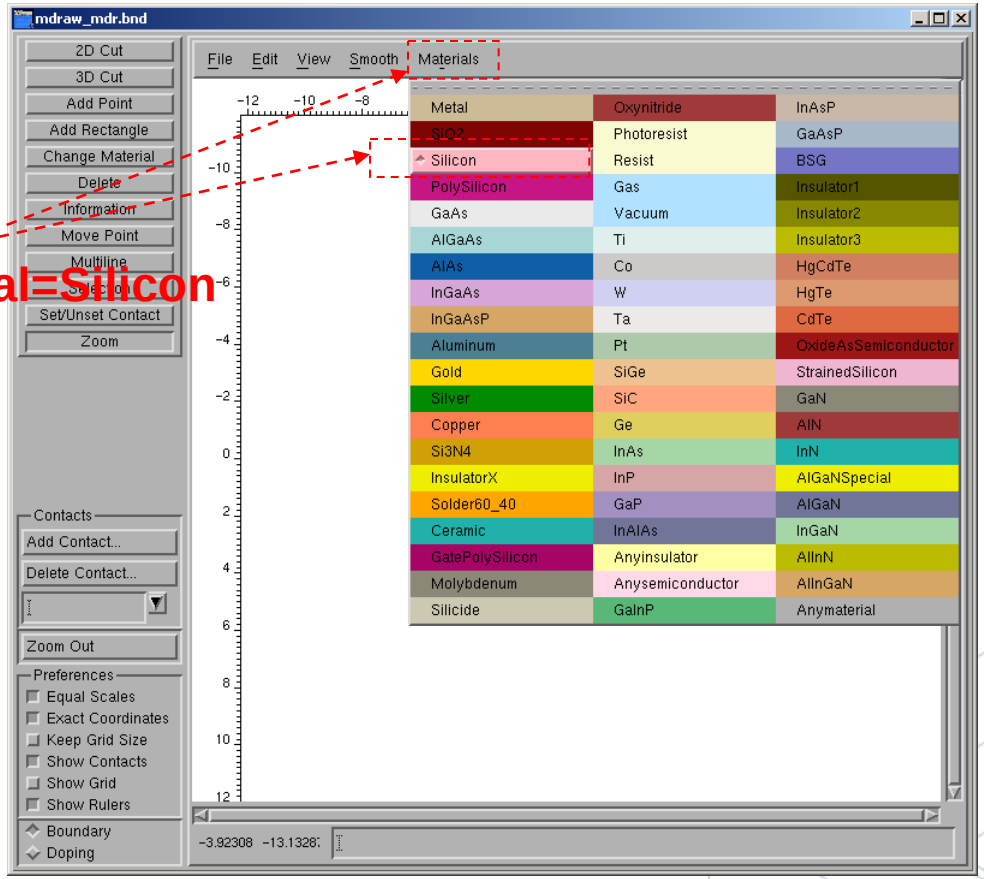
- In MDRAW you can draw free-hand. This is the default mode. However, in most cases it is advantageous to place points accurately. It is thus recommended to activate the Exact Coordinates option from the **Preference Area**. When this option is checked, a dialog window will open after each mouse placement in which you can specify the exact placement coordinates.



Setting the Current Material

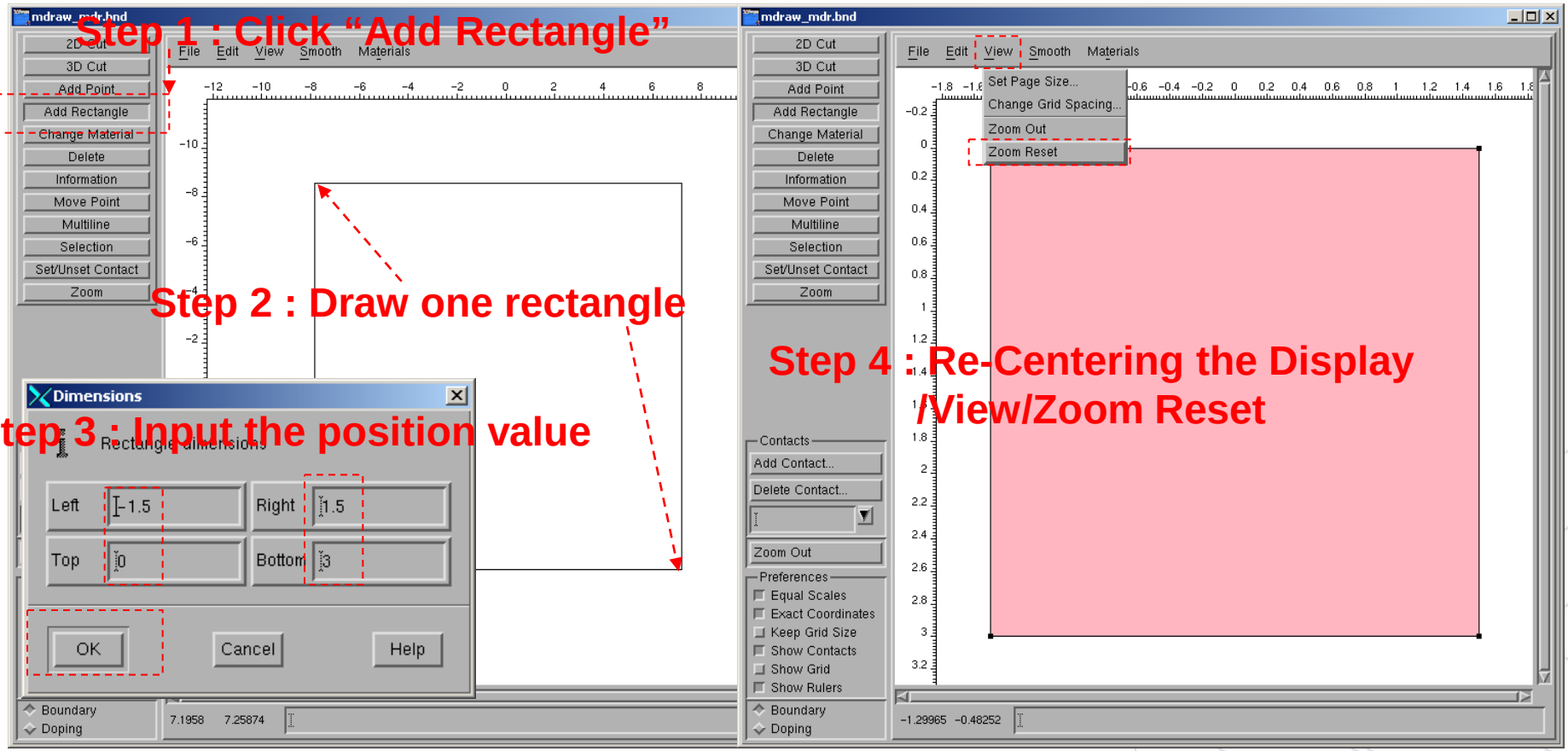
- To select the material for consecutive operations, open the Materials pull-down menu from the **Menu Bar**. Then click on the desired material, e.g., Silicon.

Step 1 : Click Material=Silicon



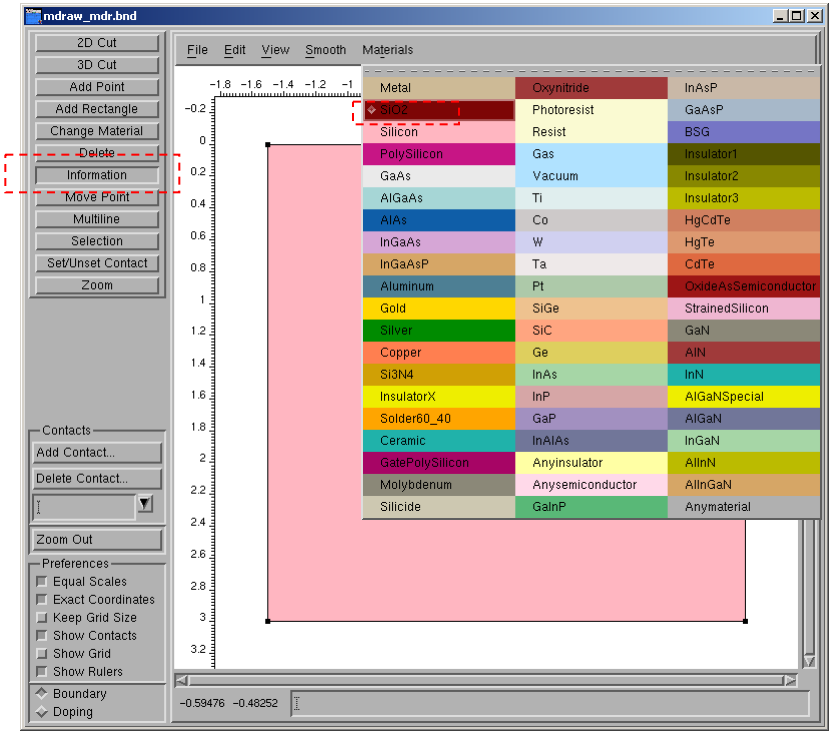
Adding a Rectangle

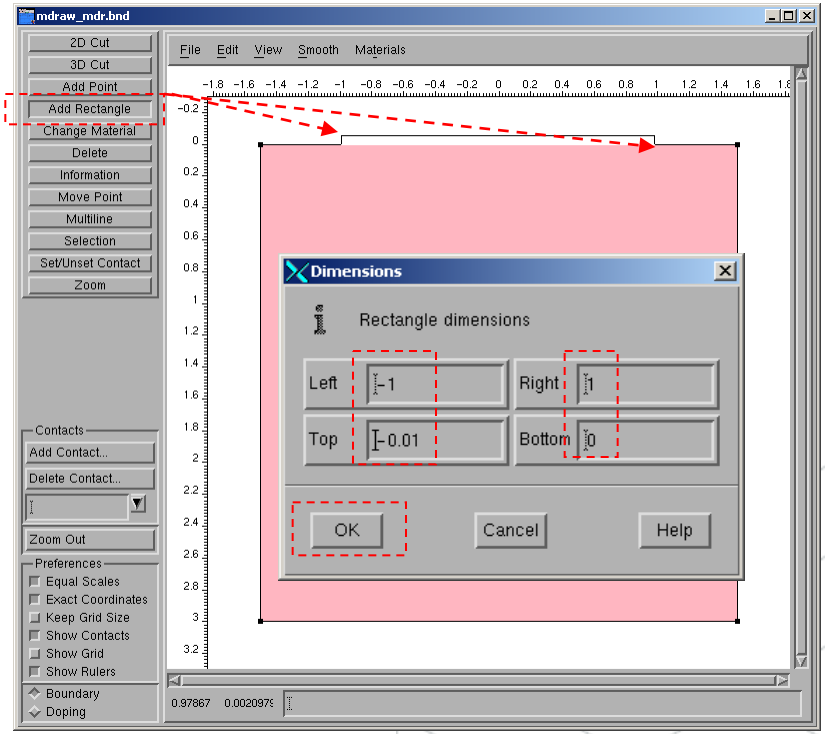
- We are now creating the silicon substrate:
  - Select Add Rectangle from the **Toolbox**.



Adding the Gate Oxide

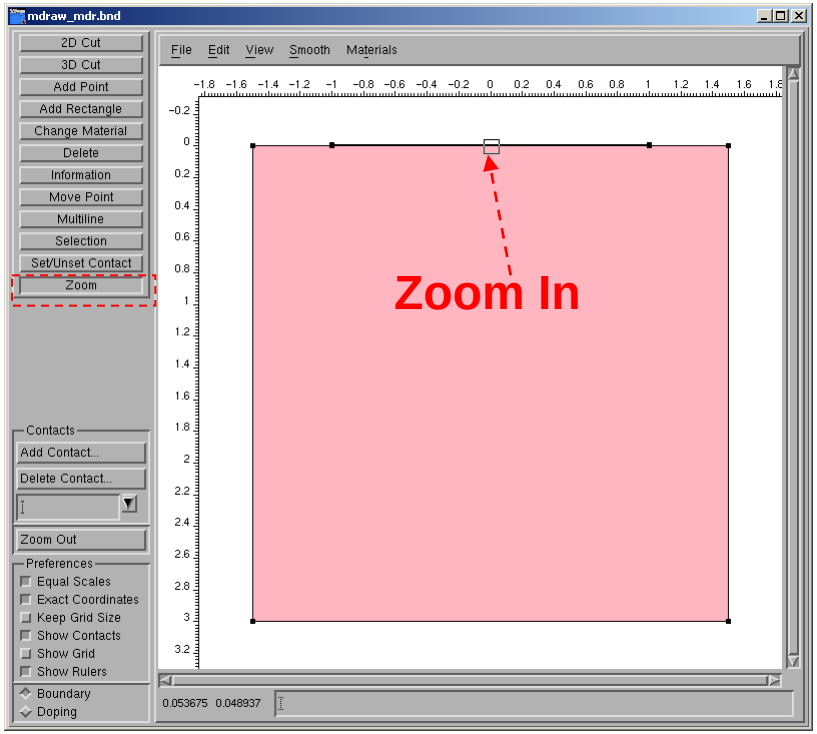
- We are now adding a 100Å gate oxide layer:
  - Set the current material to SiO2. Click here for details
  - Select Add Rectangle from the **Toolbox**.

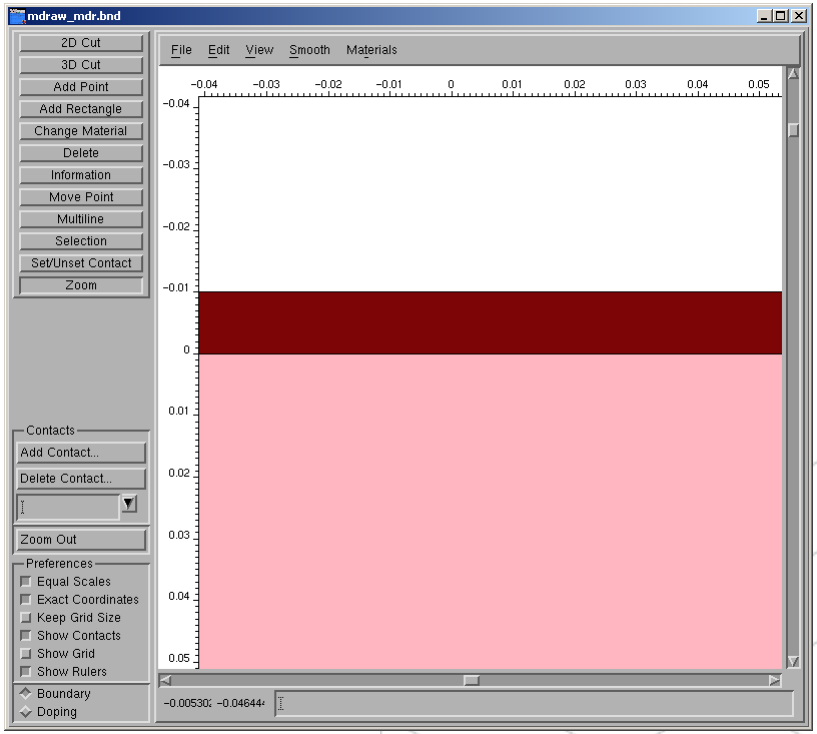




Zooming

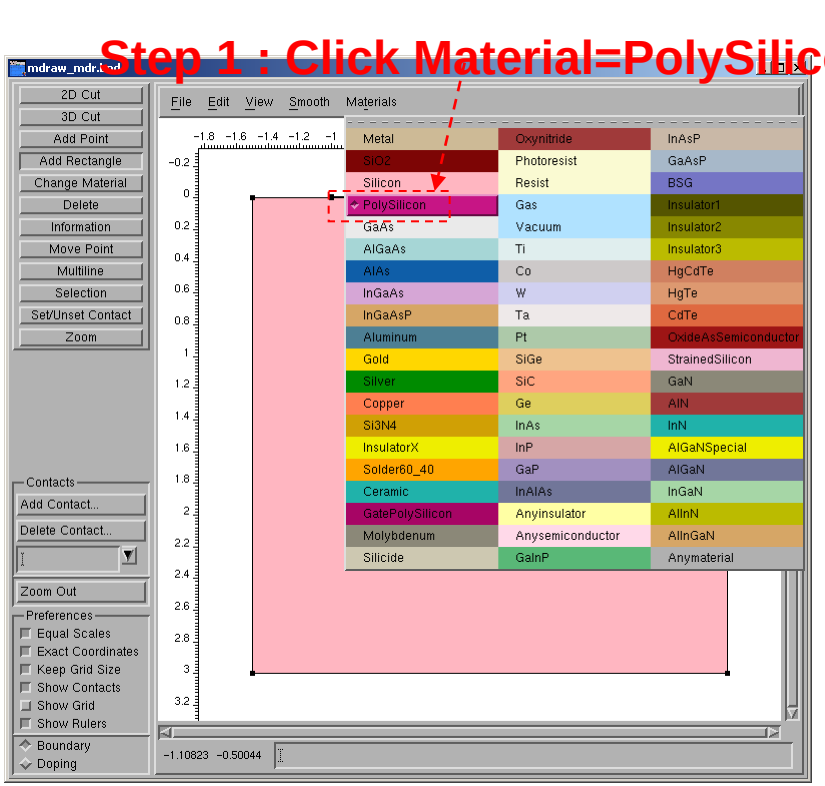
- To see the gate oxide layer, select Zoom from the **Toolbox** and drag the pointer to draw a rectangle covering the approximate area of the interest. Click here for details on re-centering the view

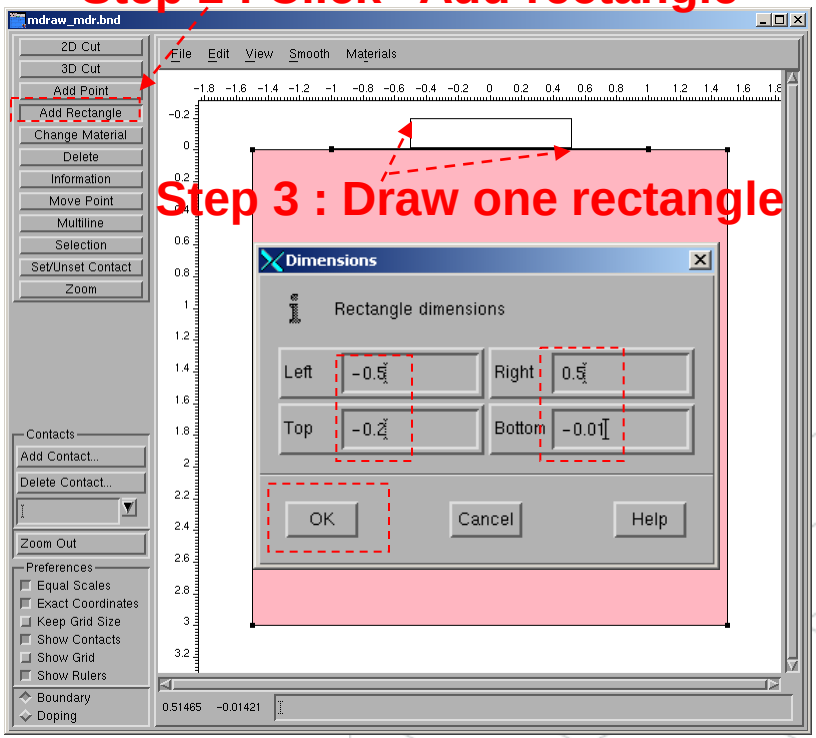




Adding the Gate Poly Silicon

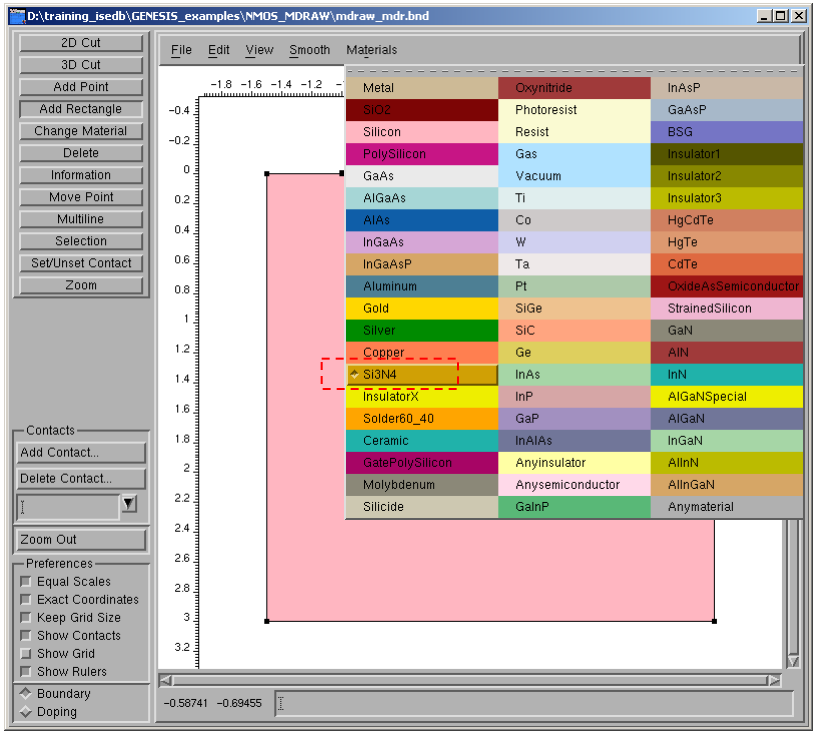
- We are now adding the gate polysilicon layer:
  - Set the current material to PolySilicon.
  - Select Add Rectangle from the**Toolbox**.

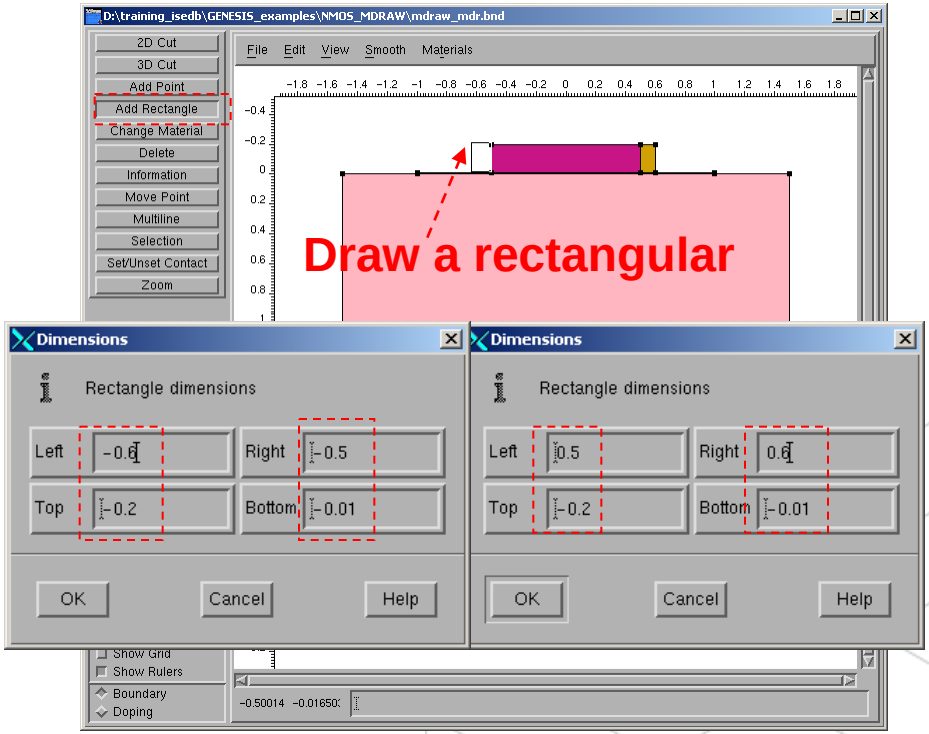




Adding Non-Rectangular Regions : Ni Spacer

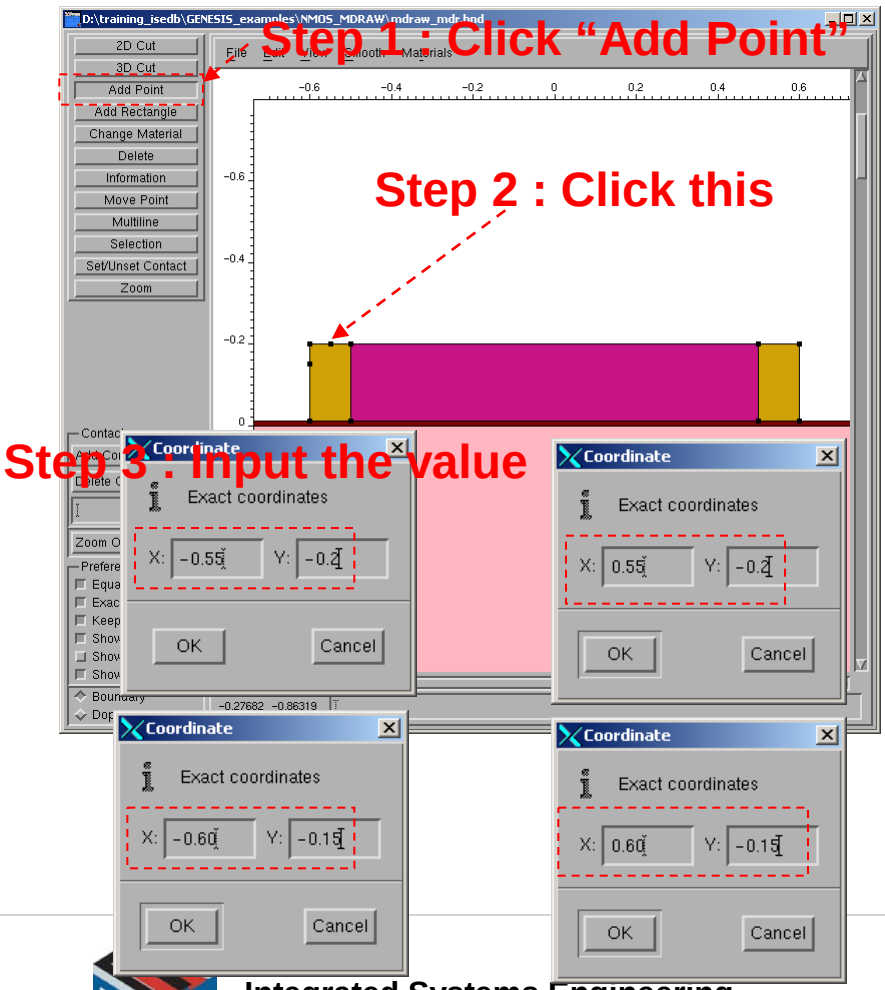
- We are now adding the nitride spacers.
  - Adding the first rectangular region. Then placing additional points and moving them to create rounded corners;

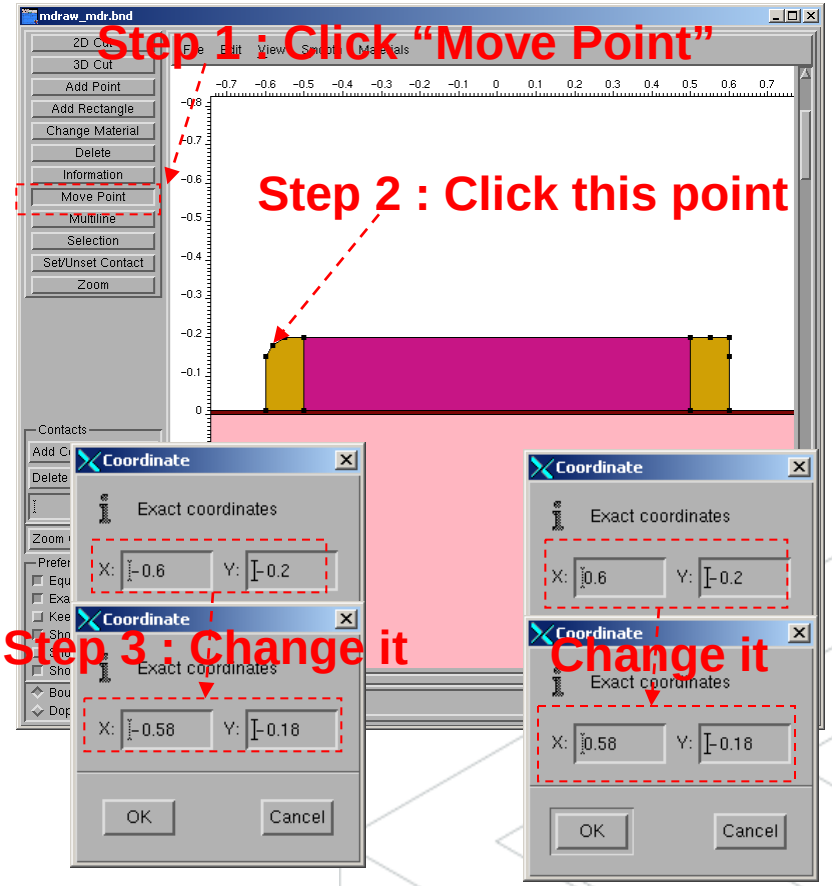




Add point and Move point

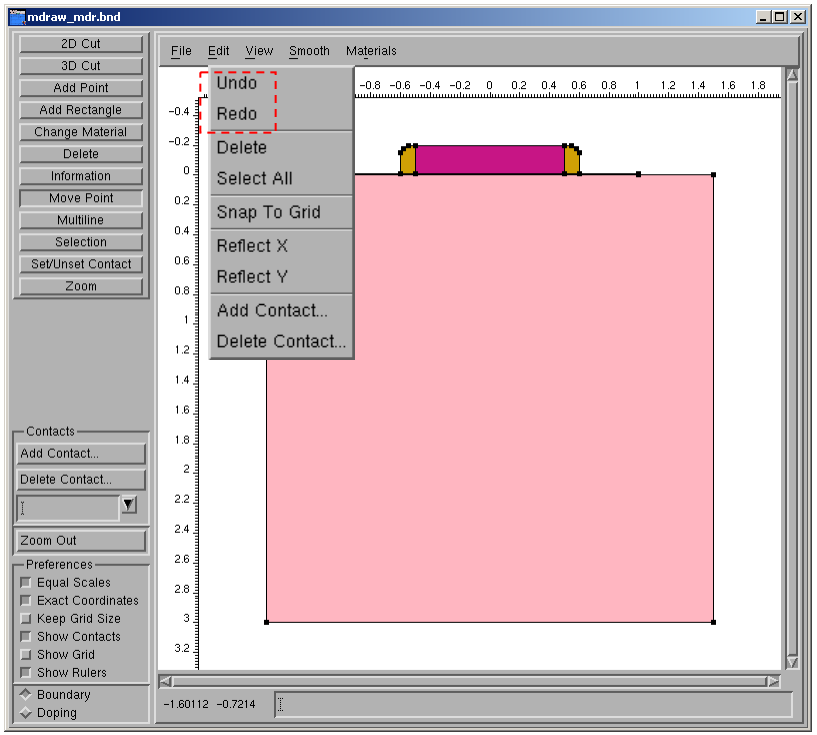
- Select Add Point from the **Toolbox** and click on several locations at the top and left edges of the nitride region.





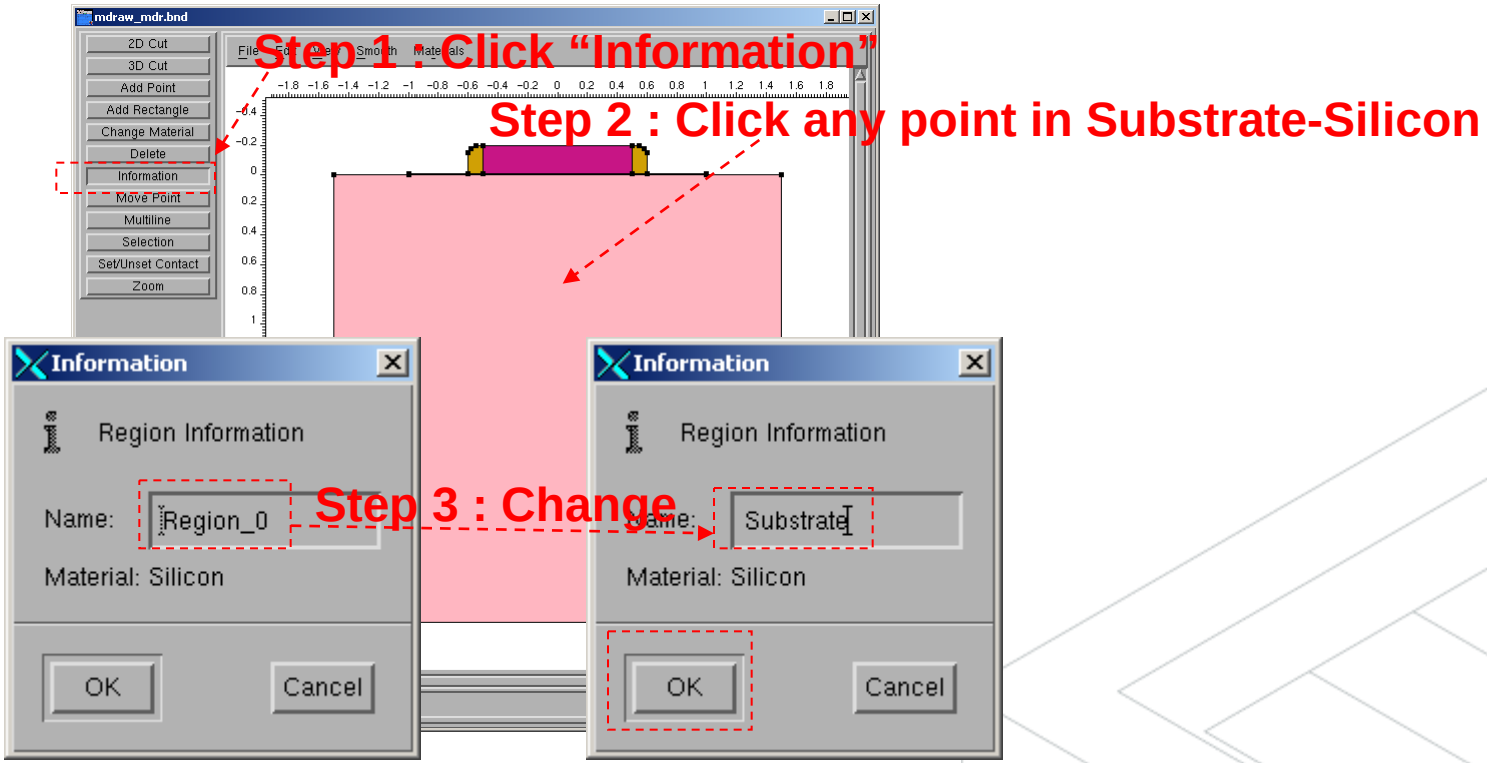
Undo and Redo

- Free-hand operations often need to be redone a few times to get them right. Open the Edit pull-down menu from the **Menu Bar** and select Undo or Redo as many times as needed.



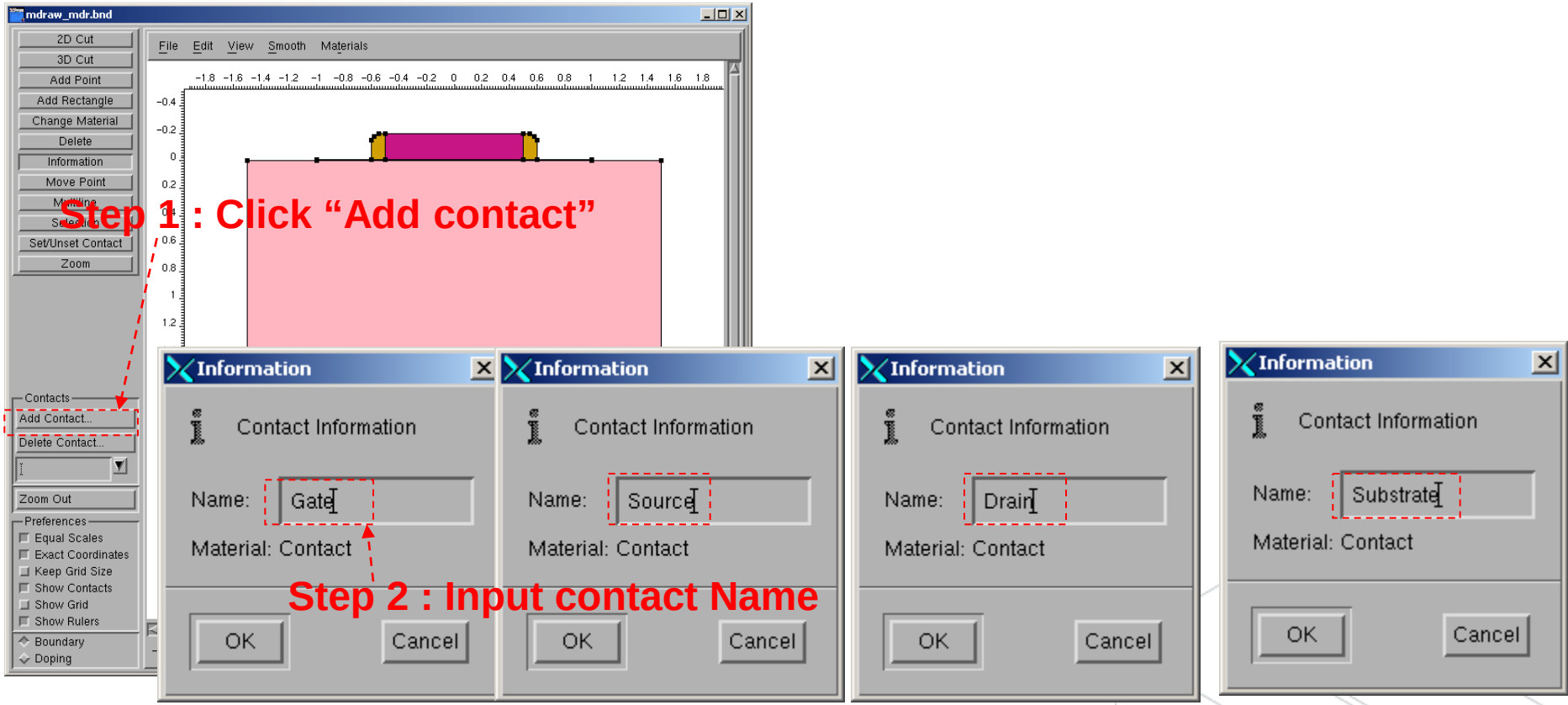
Naming Regions

- By default, MDRAW assigns names to regions in the following fashion: Region_1, Region_2, Region_3, and so forth. Here is how you can change region names:
- Select Information from the **Toolbox** and click on a layer of interest. A **Region Information** dialog window will appear which shows the material and the regionnames.



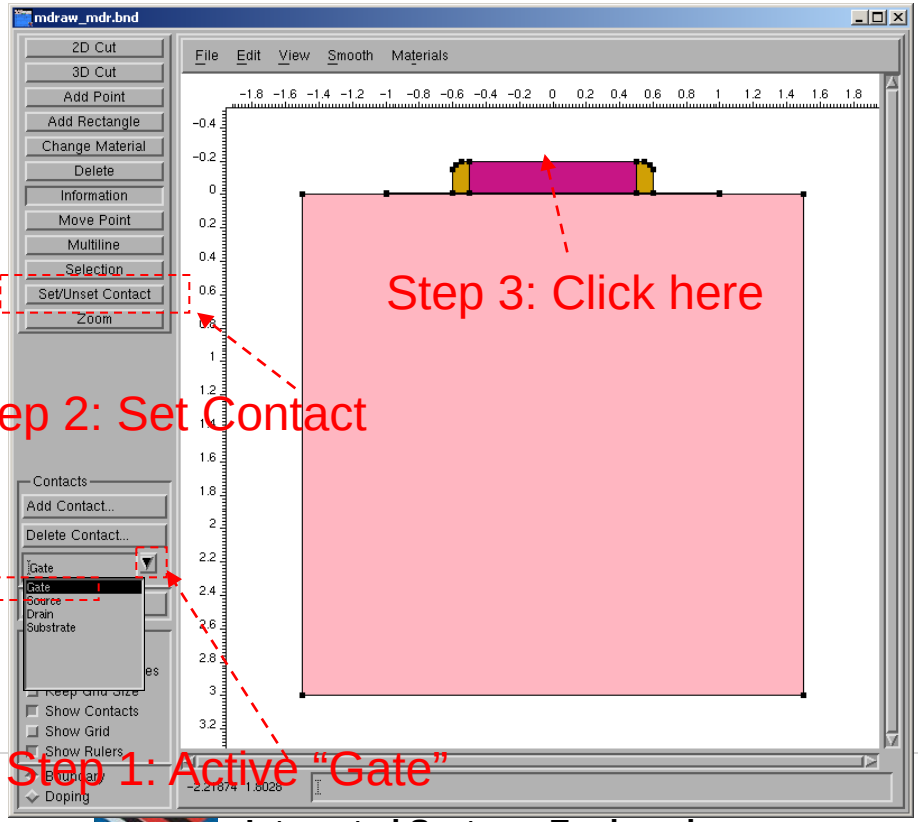
Setting Contacts

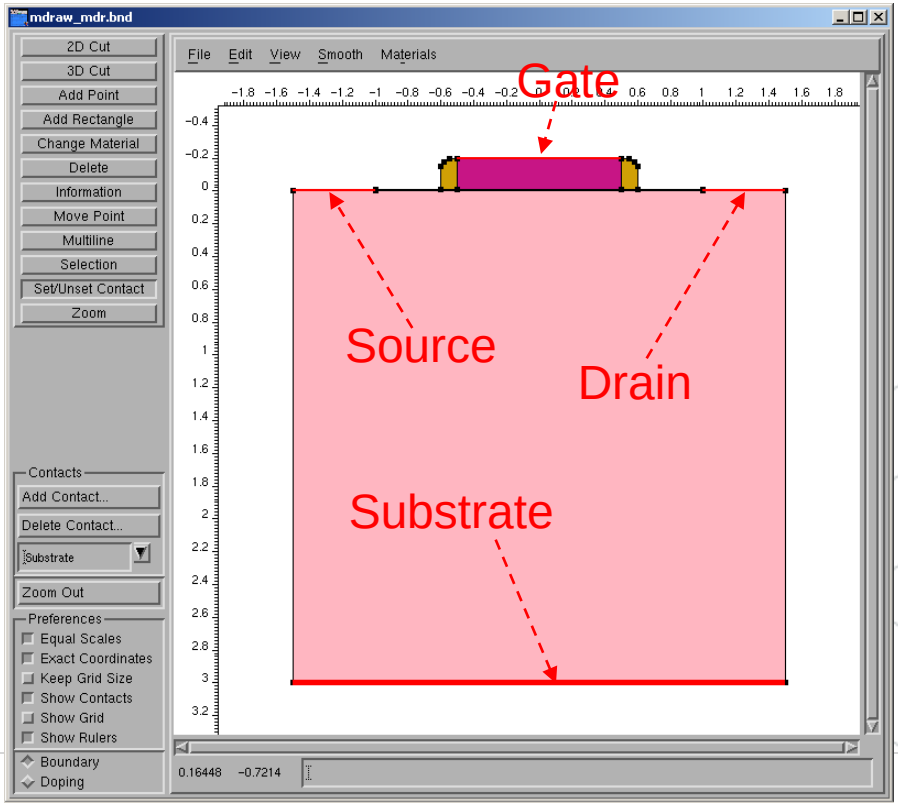
- Declare a contact by selecting Add Contact from the **Contacts Area**. A **Contact Information** dialog window will appear. Enter the name gate and click OK.



Active Contact

- To change the active contact, open the pull-down menu by clicking on the black triangle and select one
- To select edges to be added to the currently active contact, select Set/Unset Contact from the **Toolbox** and click on the respective edges. A thick red line indicates the active contact.

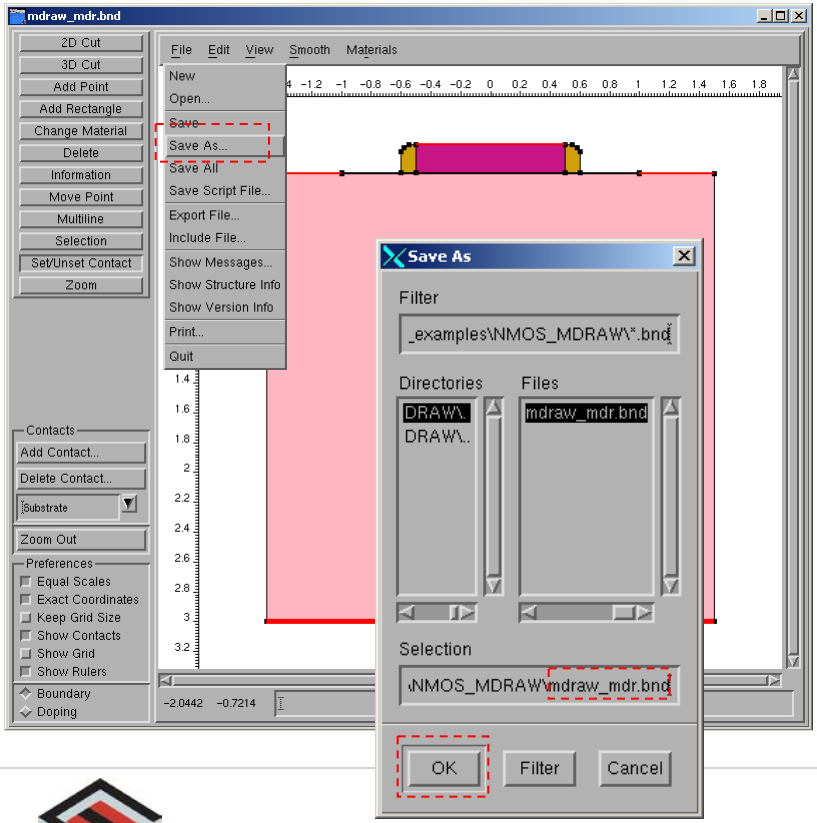




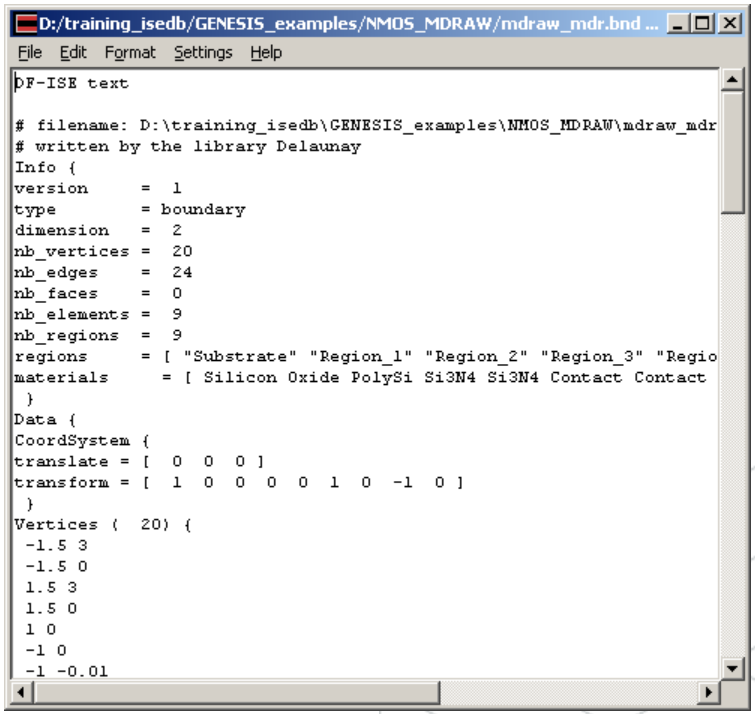
Saving the Boundary File

- The information about the device geometry is stored in a boundary file which has the extension ***.bnd**. To save a boundary file, open the File pull-down menu from the **Menu Bar** and select Save or Save As. If

Save as “mdraw_mdr.bnd”

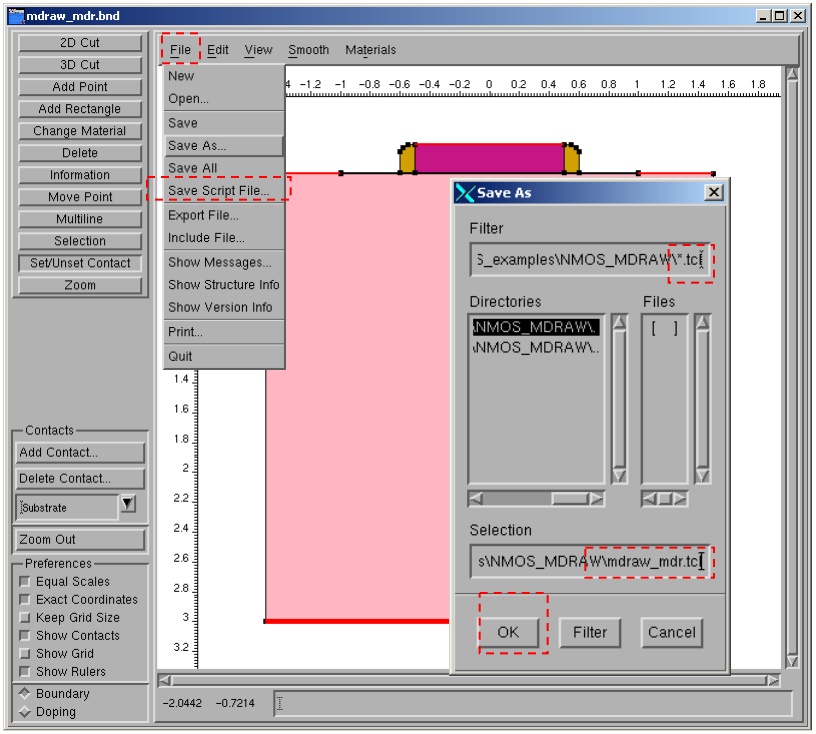


A part of mdraw_mdr.bnd

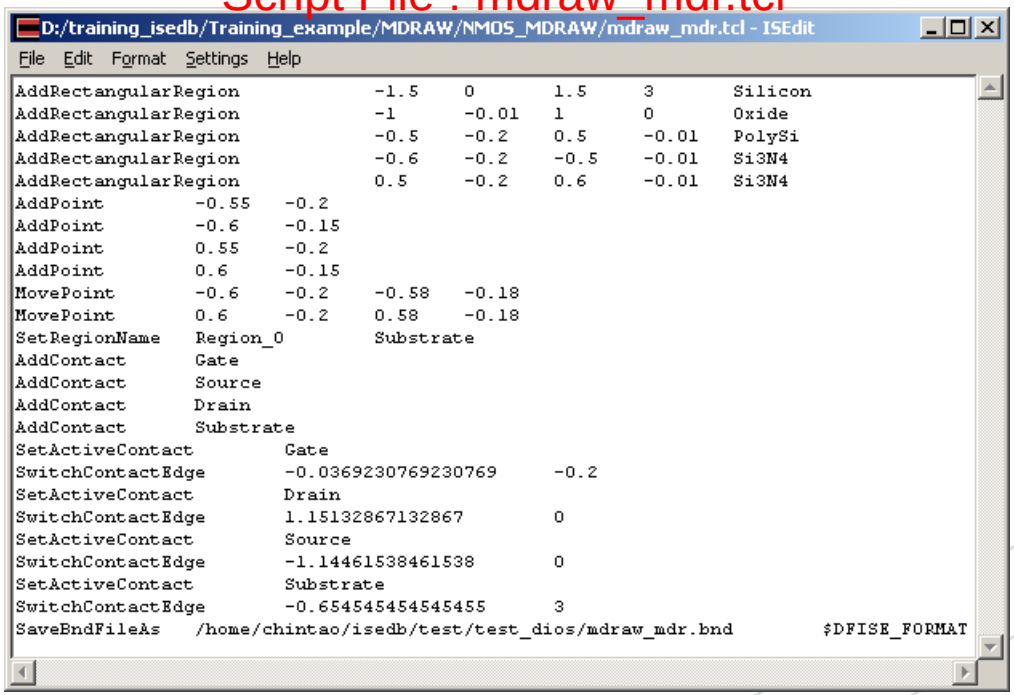


Save the Script File

- The Script file can be parameteried.



Script File : mdraw_mdr.tcl

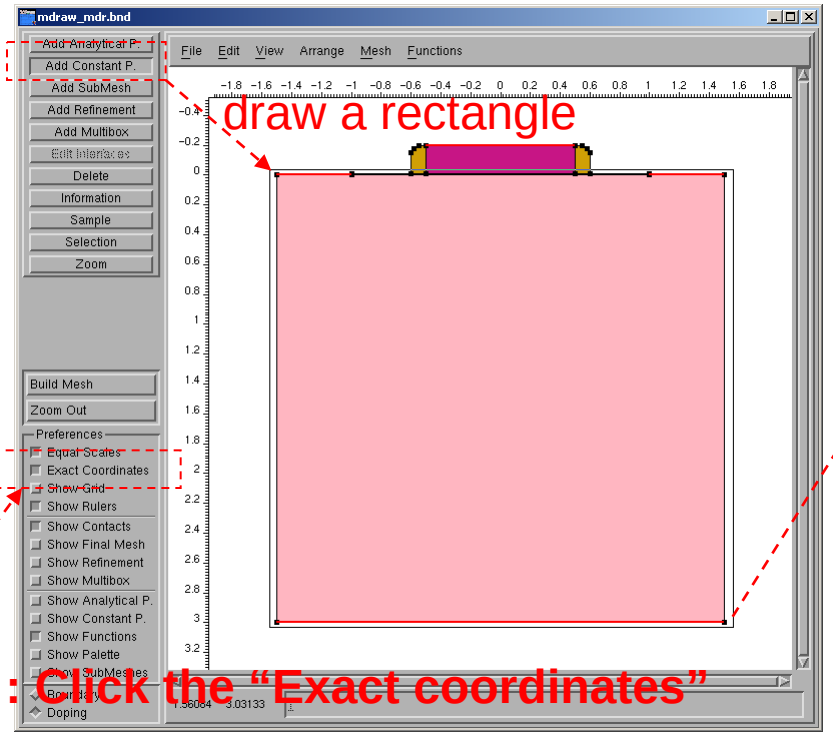


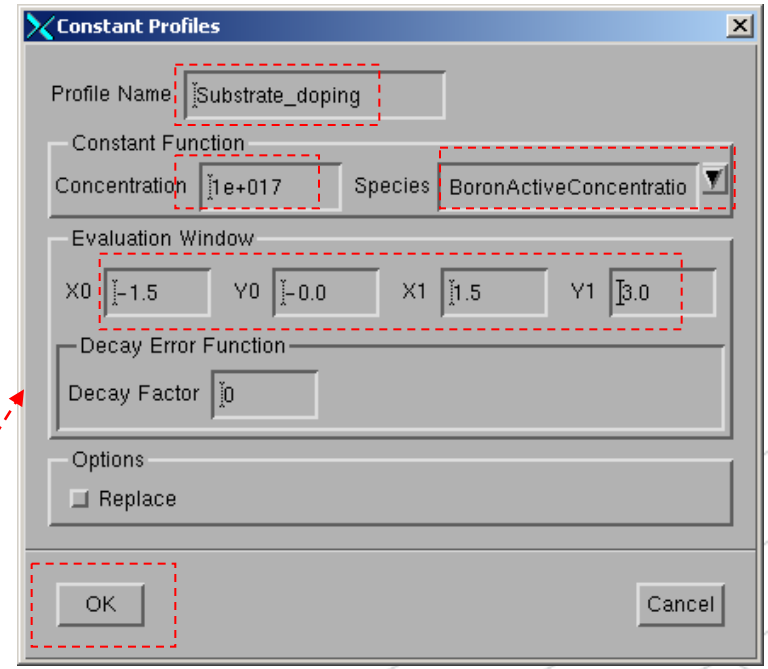
- You can run “Mdraw –L mdraw_mdr.tcl” to produce the mdraw_mdr.bnd

MDRAW Doping Editor

Adding a Constant Substrate Doping Profile

- Select Add Constant P. from the **Toolbox**.
- Press and hold the left mouse button and drag the pointer to draw a rectangle covering the approximate area of the substrate, then release the mouse button.

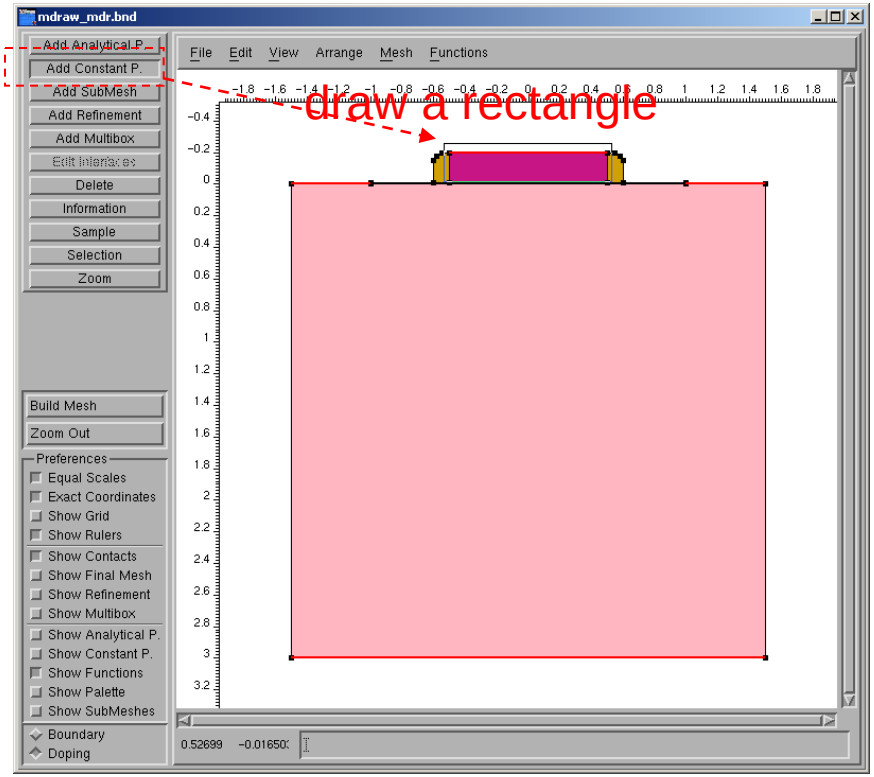


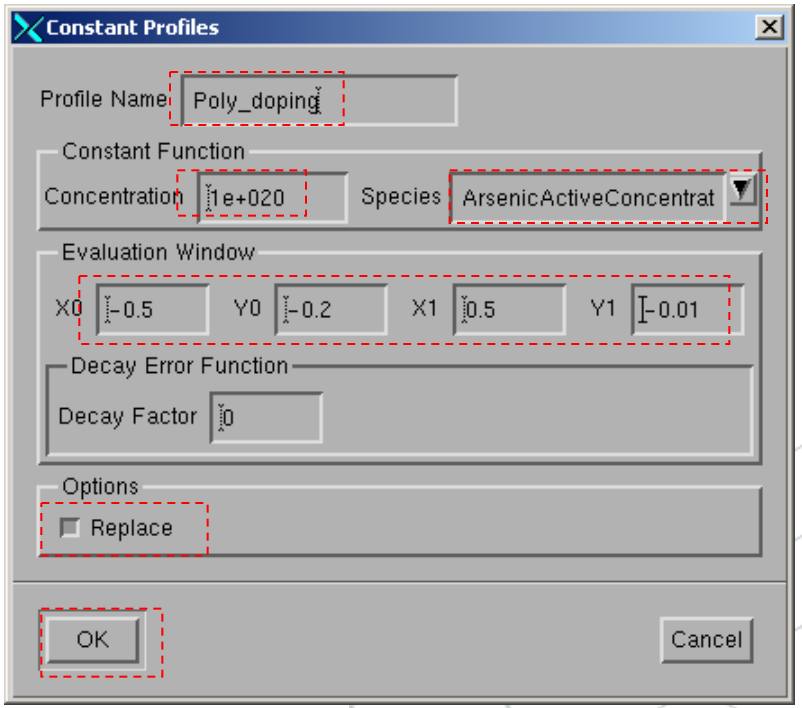


Step 1 : Click the "Exact coordinates"

Adding a Constant Poly Doping Profile

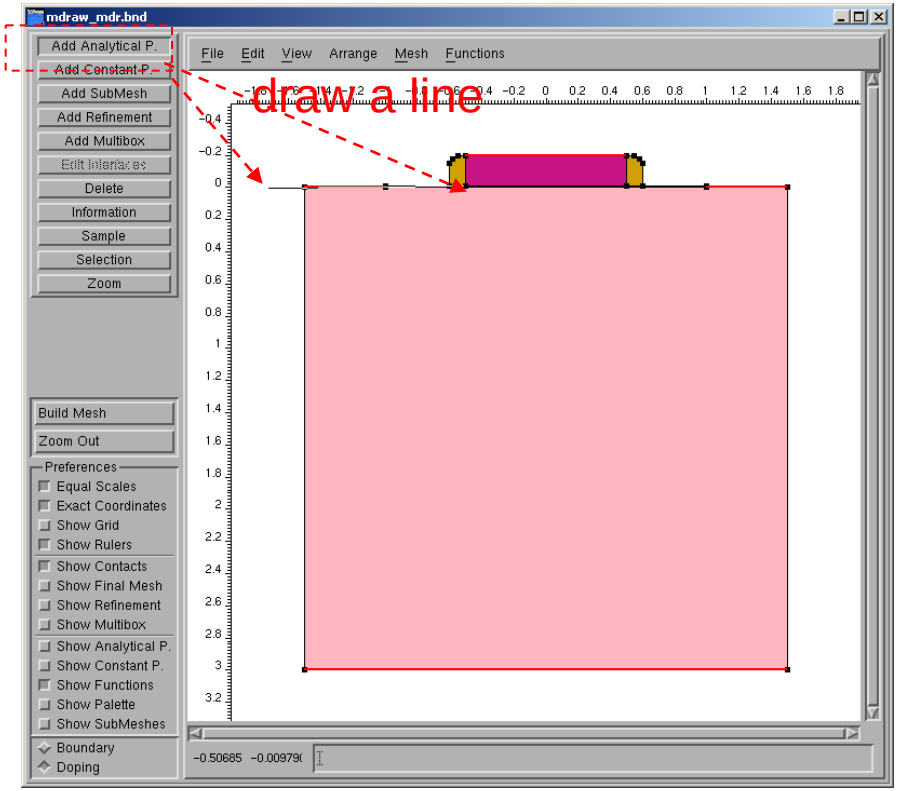
- Select Add Constant P. from the **Toolbox**.
- Press and hold the left mouse button and drag the pointer to draw a rectangle covering the approximate area of the substrate, then release the mouse button.

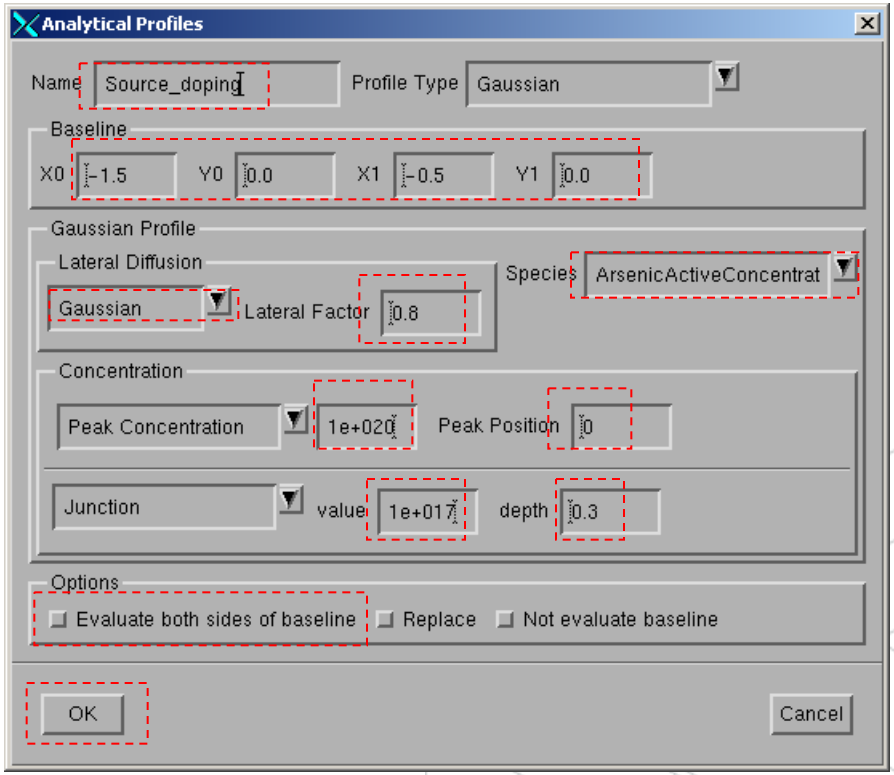




Adding an Analytical Doping Profile : Source

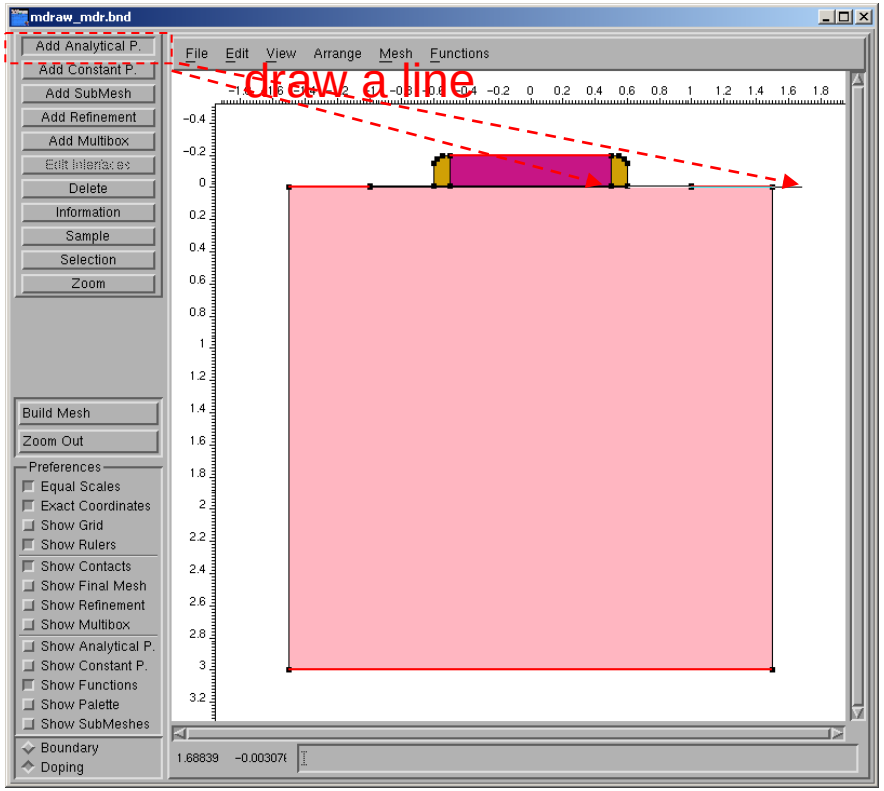
- Select Add Analytical P. from the **Toolbox**.
- Press and hold the left mouse button and drag the pointer to draw a line from left to right along the approximate extension of the source contact, then release the mouse.

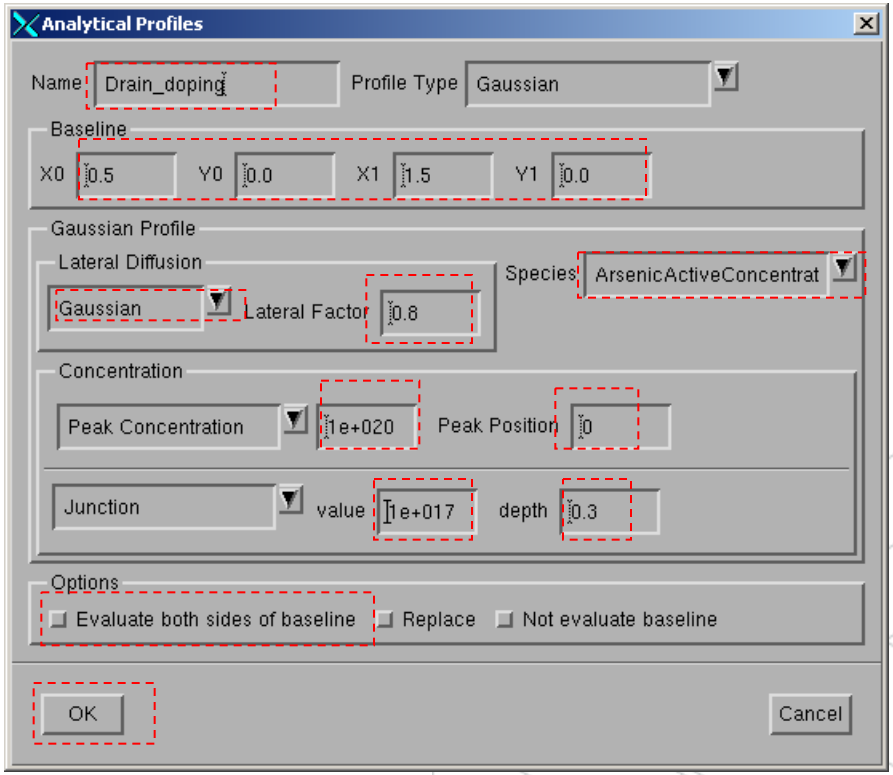




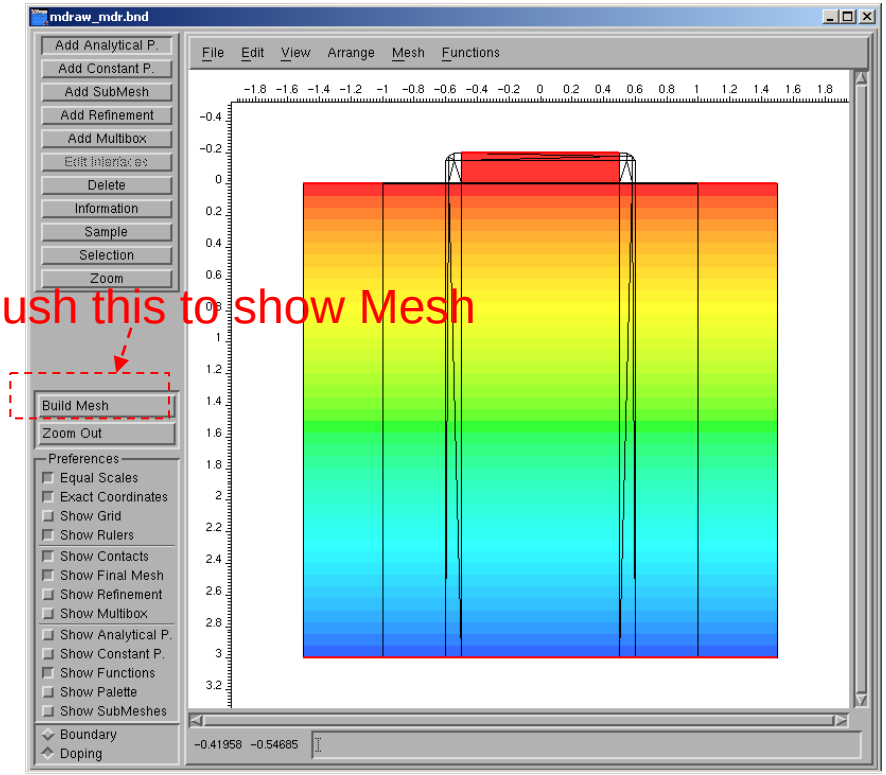
Adding an Analytical Doping Profile : Drain

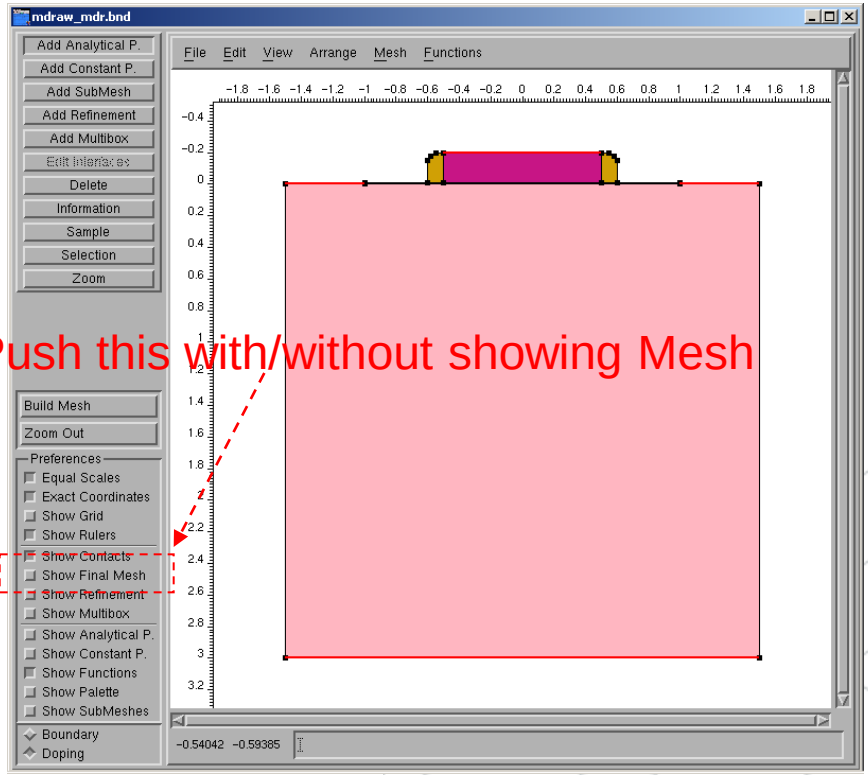
- Select Add Analytical P. from the **Toolbox**.
- Press and hold the left mouse button and drag the pointer to draw a line from left to right along the approximate extension of the source contact, then release the mouse.



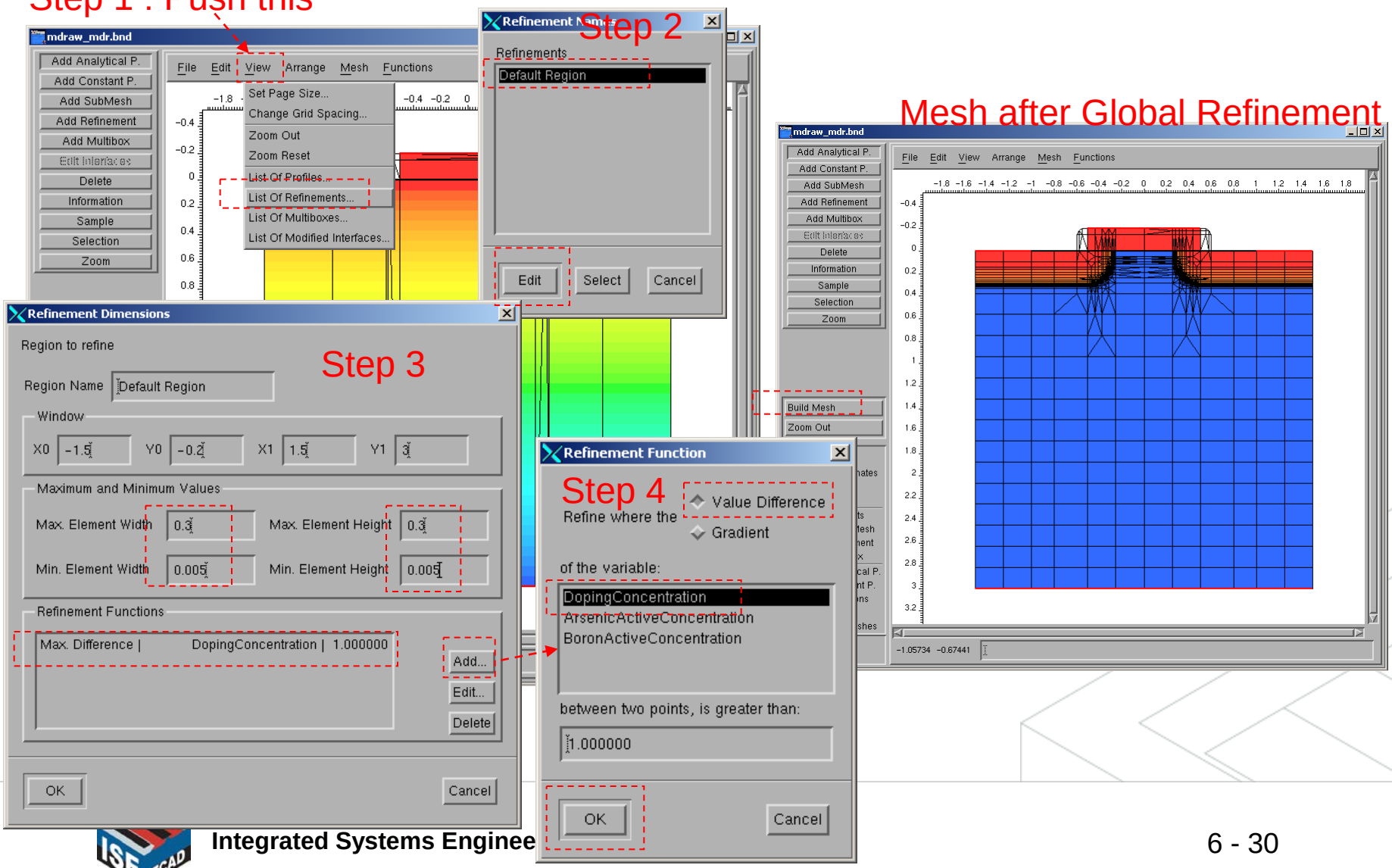


Build Mesh & Show Mesh



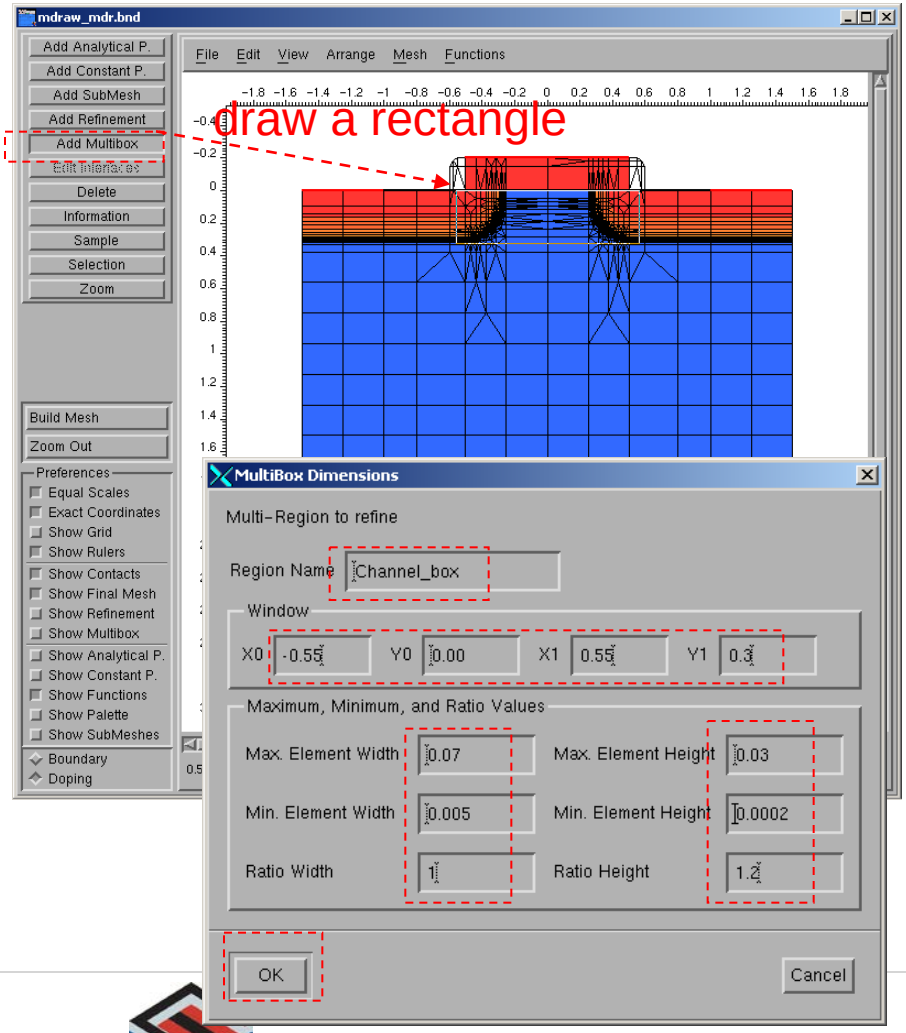


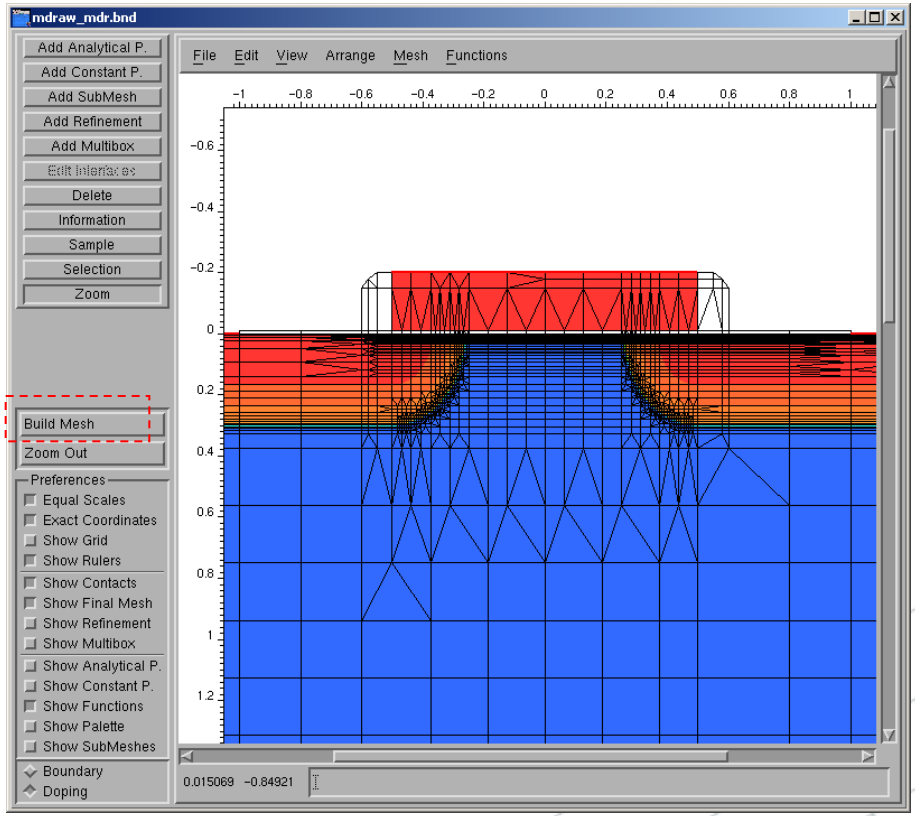
Global Refinement



Channel Multibox

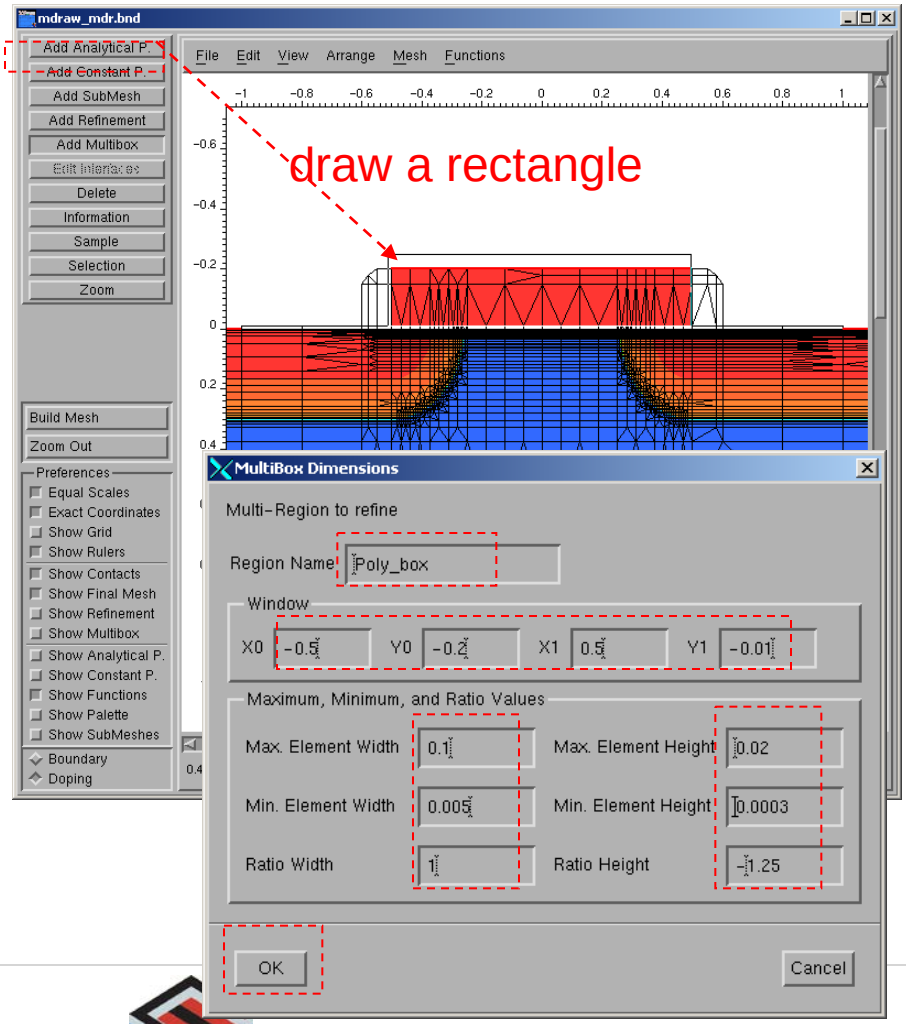
- Select Add Multibox from the **Tool Box**

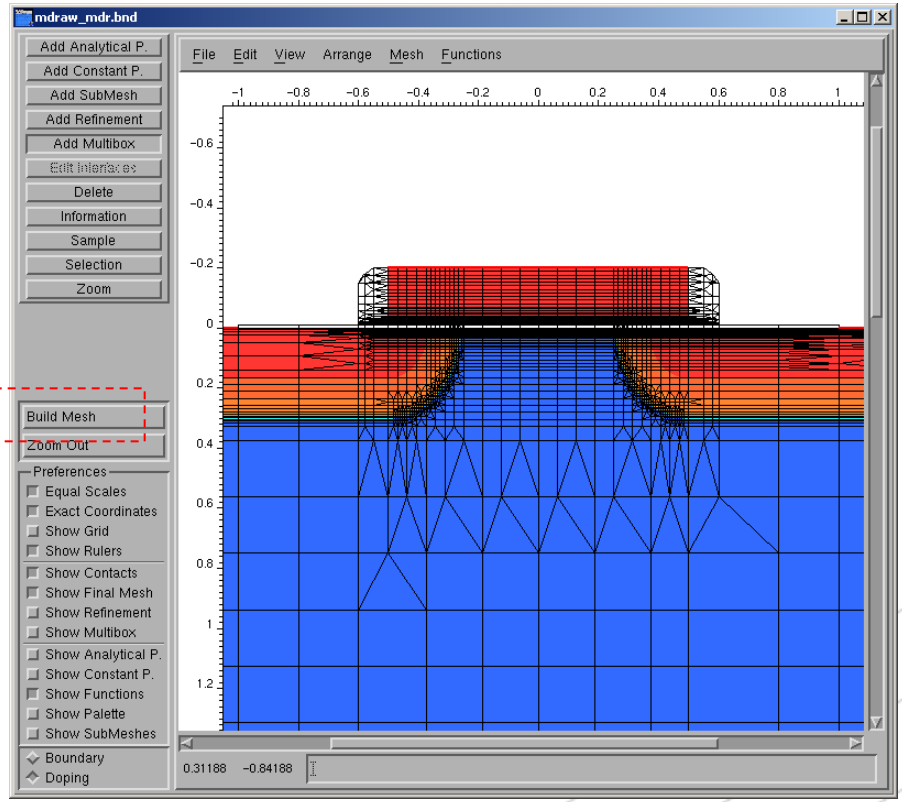




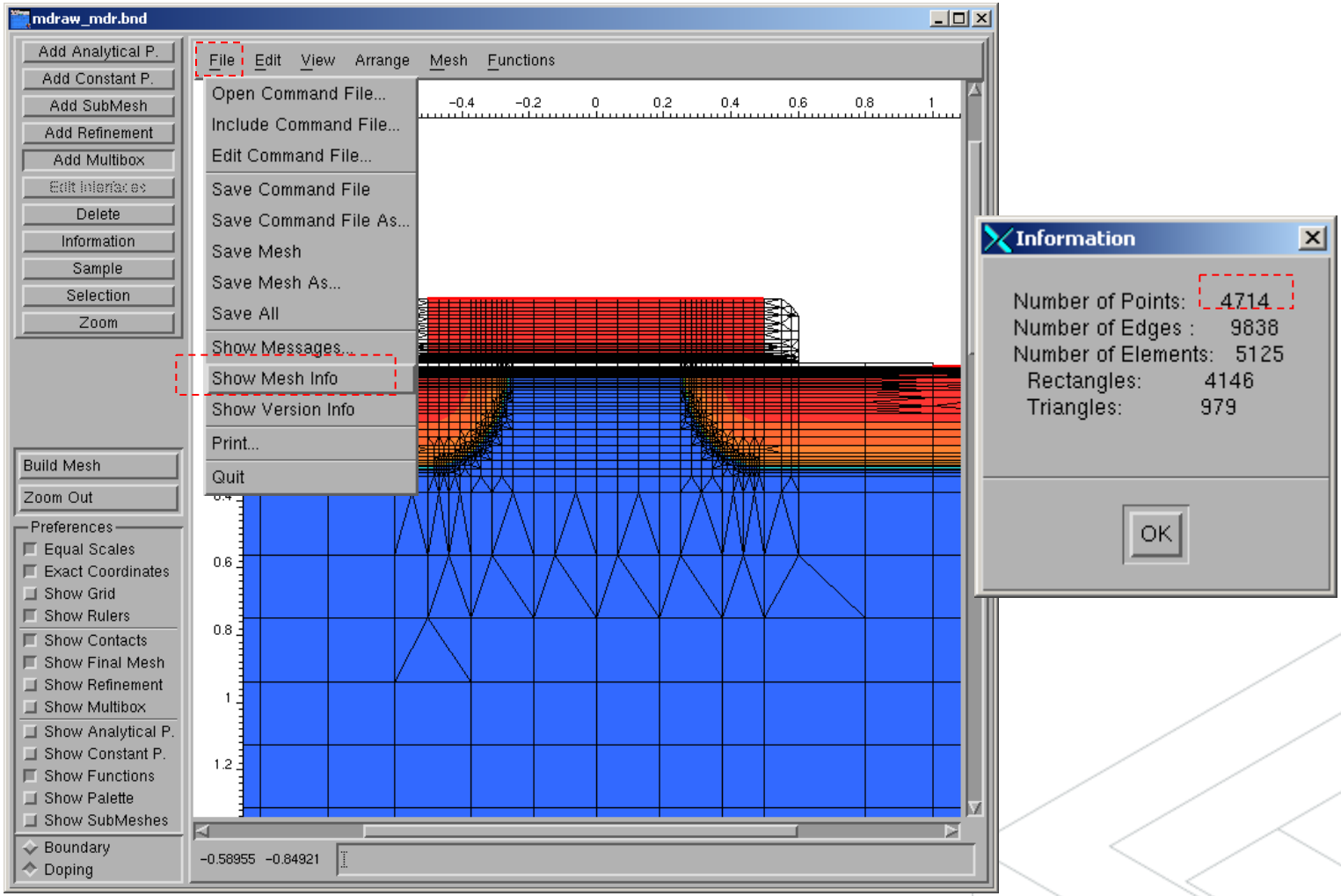
Poly Multibox

- Select Add Multibox from the **Tool Box**

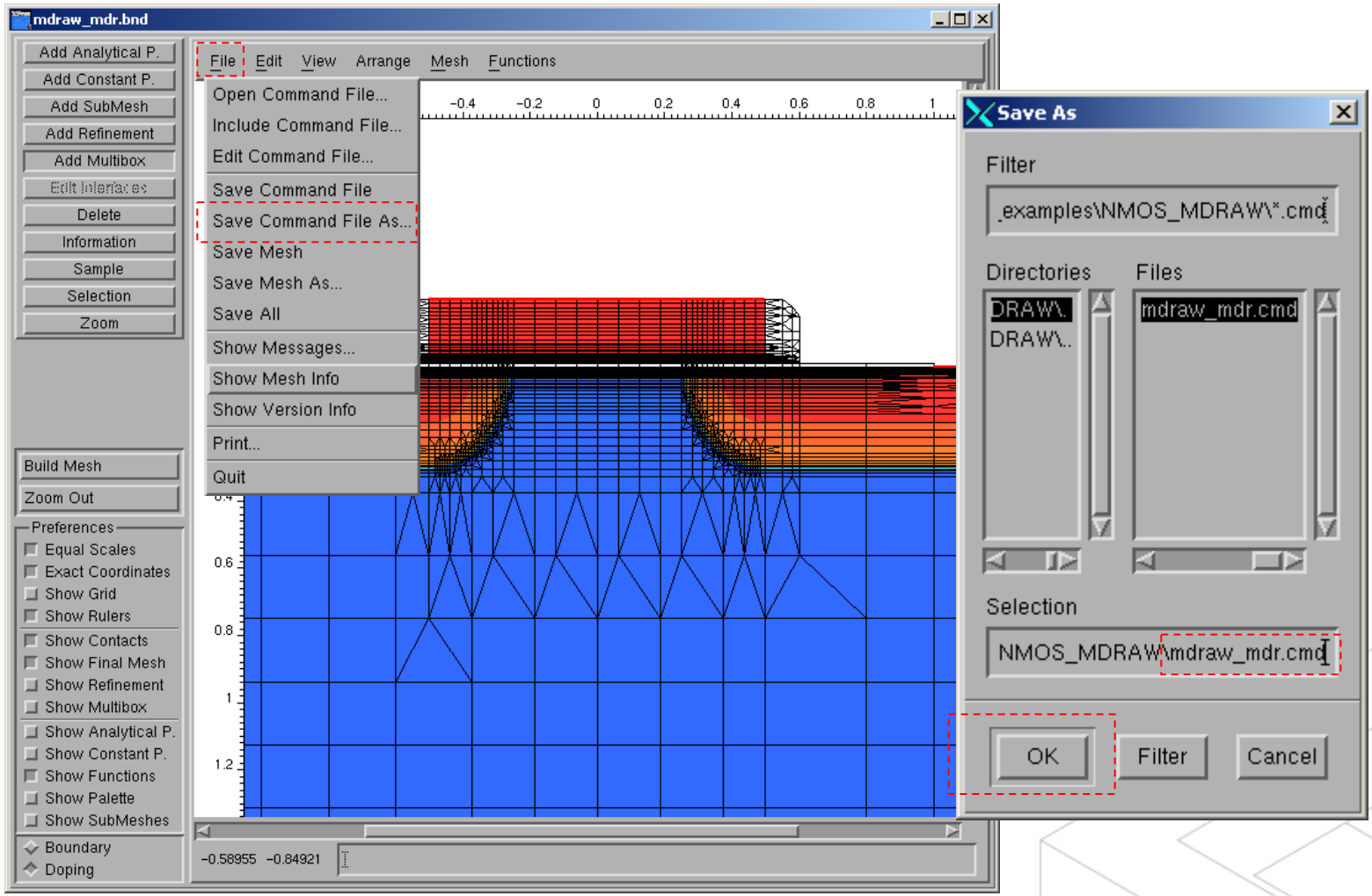




Show Mesh Numbers



Save the Command file



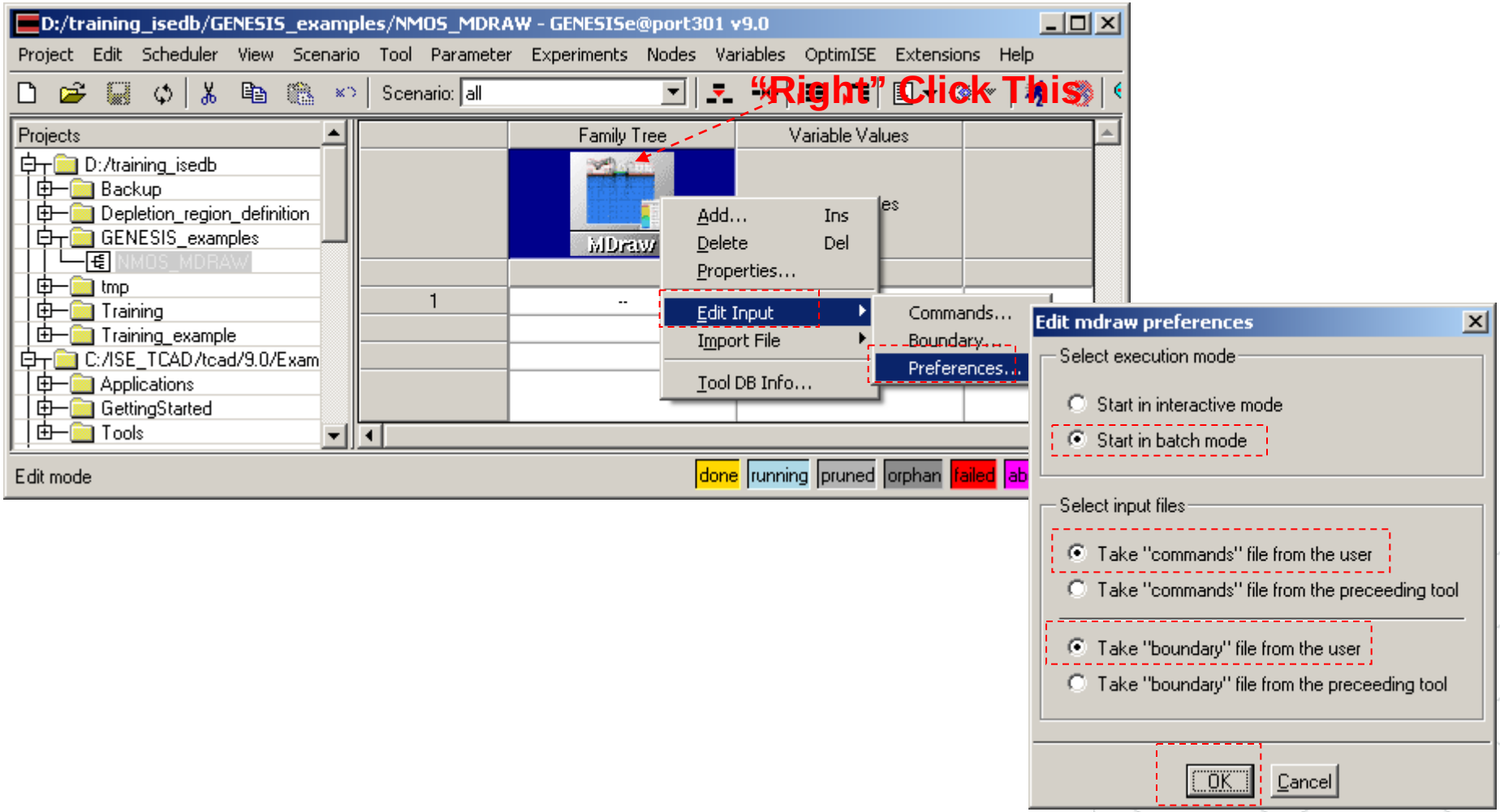
Mdraw_mdr.cmd (1)

```
Title "Untitled"

Definitions {

  # Refinement regions
    Refinement "Default Region"
    {
      MaxElementSize = (0.3 0.3 )
      MinElementSize = (0.005 0.005 )
      RefineFunction = MaxTransDiff(Variable =
"DopingConcentration", Value = 1)
    }
    Multibox "Channel_box"
    {
      MaxElementSize = (0.07 0.03 )
      MinElementSize = (0.005 0.0002 )
      Ratio = (1 1.2 )
    }
    Multibox "Poly_box"
    {
      MaxElementSize = (0.1 0.02 )
      MinElementSize = (0.005 0.0003 )
      Ratio = (1 -1.25 )
    }

  # Profiles
    Constant "Substrate_doping"
    {
      Species = "BoronActiveConcentration"
      Value = 1e+017
    }
    Constant "Poly_doping"
    {
      Species = "ArsenicActiveConcentration"
      Value = 1e+020
    }
    AnalyticalProfile "Source_doping"
    {
      Species = "ArsenicActiveConcentration"
      Function = Gauss(PeakPos = 0, PeakVal = 1e+020,
ValueAtDepth = 1e+017, Depth = 0.3)
      LateralFunction = Gauss(Factor = 0.8)
    }
    AnalyticalProfile "Drain_doping"
    {
      Species = "ArsenicActiveConcentration"
      Function = Gauss(PeakPos = 0, PeakVal = 1e+020,
ValueAtDepth = 1e+017, Depth = 0.3)
      LateralFunction = Gauss(Factor = 0.8)
    }
}
```

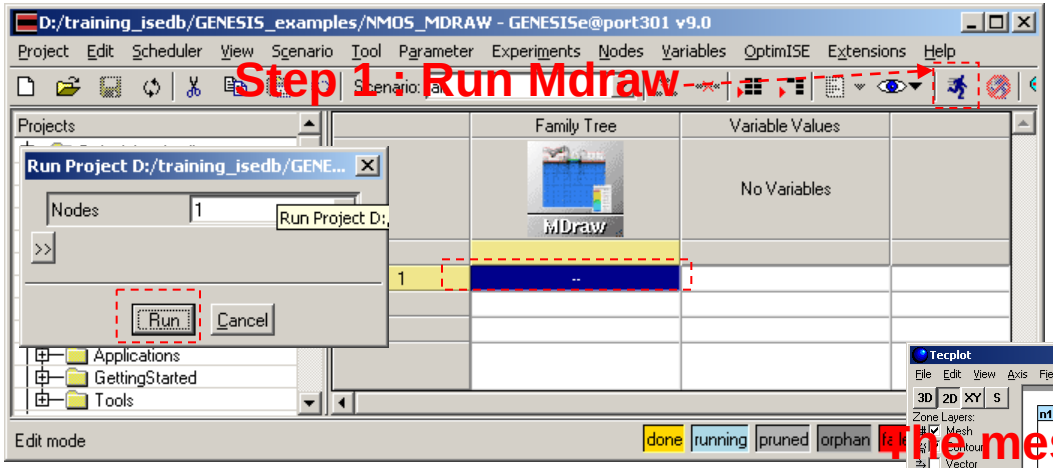
Mdraw_mdr.cmd (2)

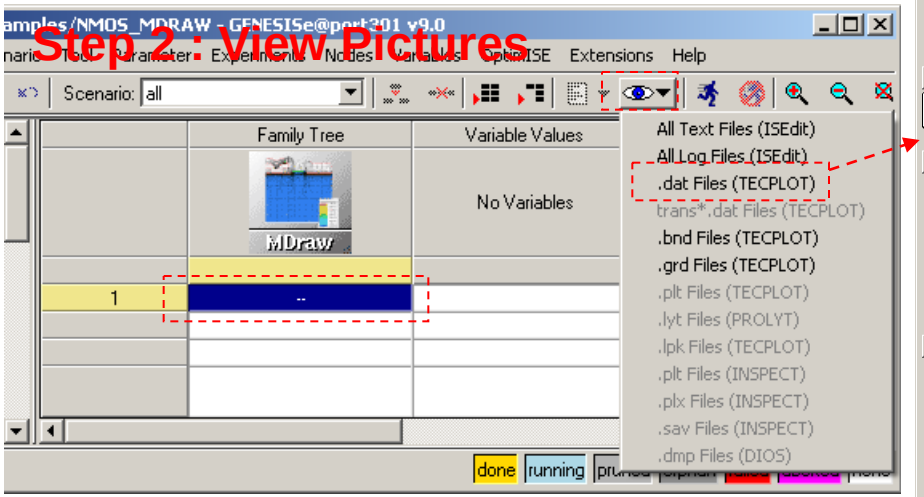
```
Placements {
  # Refinement regions
    Refinement "Default Region"
    {
      Reference = "Default Region"
      # Default region
    }
    Multibox "Channel_box"
    {
      Reference = "Channel_box"
      RefineWindow = rectangle [( -0.55 , 0  ), ( 0.55 , 0.3 )]
    }
    Multibox "Poly_box"
    {
      Reference = "Poly_box"
      RefineWindow = rectangle [( -0.5 , -0.2  ), ( 0.5 , -0.01 )]
    }
  # Profiles
    Constant "Substrate_doping"
    {
      Reference = "Substrate_doping"
      EvaluateWindow
      {
        Element = rectangle [( -1.5 0 ) , ( 1.5 3 )]
        DecayLength = 0
      }
    }
    Constant "Poly_doping"
    {
      Reference = "Poly_doping"
      Replace
      EvaluateWindow
      {
        Element = rectangle [( -0.5 -0.2 ) , ( 0.5 -0.01 )]
        DecayLength = 0
      }
    }
    AnalyticalProfile "Source_doping"
    {
      Reference = "Source_doping"
      ReferenceElement
      {
        Element = line [( -1.5 0 ) , ( -0.5 0 )]
        Direction = positive
      }
    }
    AnalyticalProfile "Drain_doping"
    {
      Reference = "Drain_doping"
      ReferenceElement
      {
        Element = line [( 0.5 0 ) , ( 1.5 0 )]
        Direction = positive
      }
    }
}
```

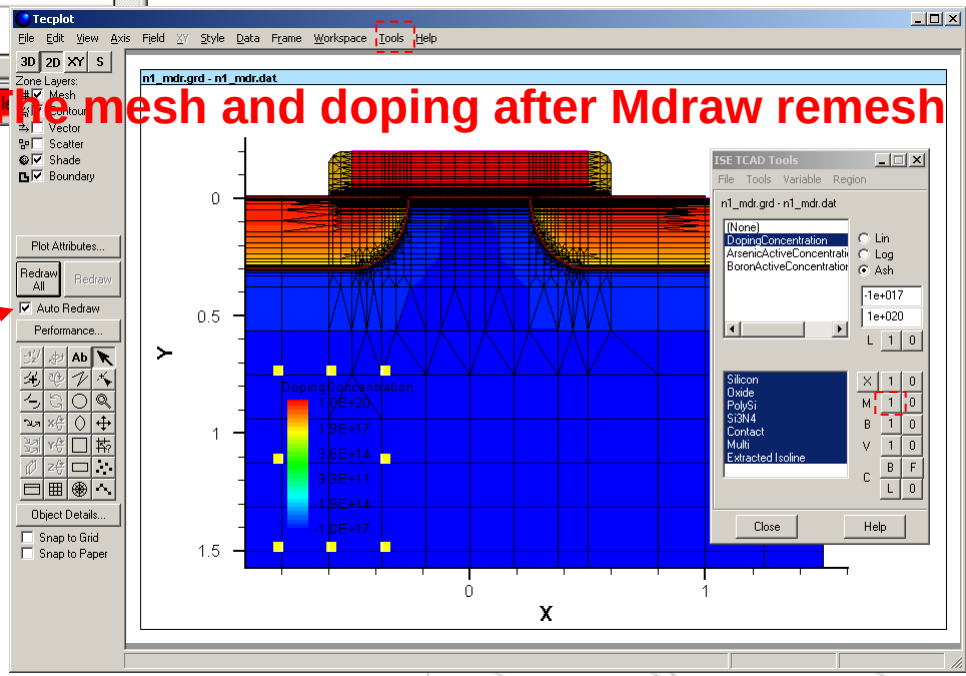
Change the Executive mode



Run MDRAW in batch mode







Type mesh and doping after Mdraw remesh

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