Exercise 4

Materials, Lists, and Groups

Objective:

- In this exercise you will define material properties and apply them as element properties on the hybrid microcircuit mesh.

- You will also use lists and groups as tools to more easily manipulate your model.
Model Description:

In this exercise you will define several groups which will contain subsets of model entities. These groups can facilitate model manipulation. You will define materials by entering the data manually based on the information provided. These materials will be applied as element properties. Lists will be used to demonstrate their utility in completing the application and verification of element properties.

Exercise Overview:

- Open the existing database named microcircuit.db.
- Use Create//Isotropic/Manual Input to define the five materials used in this model.
- Use Group/Create to define a group containing only geometry, another containing only FEM entities, and two more groups dividing the substrate FEM and the device FEM.
- Use Properties/Create/3D/Thermal 3D Solid to apply the material properties to 4 of the 5 material regions; intentionally ignore the silicon region.
- Use List/Create... and List/Boolean... to identify elements which have not had a material property applied.
- Complete application of material properties using the ‘listc’ contents as input.
- Quit MSC/PATRAN.
Exercise Procedure:

1. Open the existing database

Within your window environment change directories to the microcircuit.db working directory. Run MSC/PATRAN by typing `p3` in your xterm window.

Next, select File from the Menu Bar and select Open… from the drop-down menu. Select the name `microcircuit.db` from the Database List box.

Select OK to open the database.
MSC/PATRAN will open a Viewport and change various Main Form selections from a ghosted appearance to a bold format.

2. Define the five materials used in this model.

Define a material by selecting the Materials Applications radio button. Set the Action, Object, and Method to Create/Isotropic/Manual Input. Enter the Material Name Silicon and select Input Properties... to enter the data. In the Input Options form enter the value provided in Table 1 for Thermal Conductivity. Enter 1.0 for Density and Specific Heat; these are inert values which are required in the form but not used in a steady-state analysis. The completed form is shown below.

Select Apply to define the material.
Without closing the Input Options form edit the Material Name and repeat the steps for the remaining four materials renaming them appropriately, Solder, Alumina, Molybdenum, and Kovar. Select Cancel to close Input Options.

3. Divide the geometry and FEM into working groups.

Select Group from the Menu Bar and select Create... from the drop-down menu. Click in the New Group Name box and enter hybrid_geom; click in the Group Contents: menu and select Add All Geometry. The completed form is shown below.

Select Apply to complete the function.

Reselect Group/Create, if necessary. Click in the New Group Name box enter hybrid_fem click in the Group Contents: menu and select Add All FEM. Turn on Unpost All Other Groups. Select Apply to complete the function.

From the Menu Bar select Viewing/Named View Options... Select side_view then Close. Select Viewing/Fit View to readjust the display. This is a convenient view for creating the next two groups. This can also be accomplished using the Tool Bar Right Side View icon.
Reselect **Group/Create**. Click in the New Group Name box enter **substrate_fem**. Click in the Group Contents: menu and select **Add Entity Selection**. Turn off Make Current, Posted, and Unpost All Other Groups. From the Select Menu select the Select any FEM entity filter, third icon from the top; from the next level Select Menu select the Element filter, also third from the top; finally, in the third level Select Menu select the Hex element filter, eighth from top. Drag a rectangle around the perimeter of the substrate selecting only the 3 layers of substrate hex elements. The form is shown below.

Select **Apply** to complete the function.

**Repeat these steps dragging a rectangle around only the device area and solder to create the last group named device_fem.**
4. Apply the material properties to 4 of the 5 material regions; intentionally ignore the silicon region.

Select the Properties Applications radio button. Set the Action, Dimension, and Type to Create/3D/Thermal 3D Solid. Enter Property Set Name prop_kovar. Select the Input Properties... box. In the Input Properties form, click in the Material Name box and select Kovar from the Material Properties Sets list. Select OK to close the form.

Click in the Select Members box. From the at the bottom of the screen select the Select a Solid element filter, second icon from the top, and drag a rectangle around the lowest layer of hex elements, region E in Figure 1. The completed form is shown below. Select Add then Apply to complete the function.

Repeat these steps for the next three layers of elements naming the properties prop_moly, prop_alumina, and prop_solder. Be certain to select the appropriate material for each layer. Omit assigning element properties to the silicon devices. Refer to Figure 1 for material locations.
We are intentionally omitting the application of a material property to some elements. However, it is not unusual in practice to inadvertently omit assigning an element property to some elements. Use lists to recover them.

5. Identify elements which do not have a material property applied.

Select Tools from the Menu Bar and select List from the drop-down menu and Create… from the submenu. Set the Model, Object, and Method to FEM/Element/Association. In the Association frame scroll to and select Group. In the Existing Groups frame select hybrid_fem. Select Apply. All elements will be listed in ‘lista’ contents:

Find Target List at the bottom of the Create List form select “B”. Set the Model, Object, and Method to FEM/Element/Attribute. In the Attribute list select Material. In the Existing Materials list drag through all listed materials and select all materials. Select Apply. Elements with defined materials are listed in ‘listb’ contents:

The resulting forms are shown below.
Since Lista A contains all elements and List B contains all elements with a material attribute, subtracting List B from List A will yield List C which will contain all elements which do not have material attributes.

Select Tools/List from the Menu Bar and select Boolean… from the submenu. The Boolean List form will offer several options for Boolean operations, choose the A-B icon. The variable ‘listc’ now contains the desired element list. Select Cancel to exit the Boolean List and select Cancel again to exit the Create List form. The contents of ‘lista’, ‘listb’, and ‘listc’ are retained.

MSC/PATRAN supplies a set of utilities collected under the name Utilities. When installed, Utilities provides a utility, Utilities/Group/Group Elements with No Properties..., which accomplishes the preceding steps in three mouse clicks. We will discuss and use Utilities in later lectures and exercises.

6. Complete application of material properties using the ‘listc’ contents as input.

To complete element properties return to Create/3D/Thermal 3D Solid. Change the Property Set Name to prop_silicon. Complete the Input Properties form by selecting Silicon from the Material Property Sets. In the Select Members box type ‘listc’ (use reverse apostrophes). Notice that ‘listc’ is evaluated in the Application Region. Select Add then Apply to complete the function.

From the Menu Bar select Viewing/Named View Options... from the drop-down menu. Select isometric_view select Apply Named View then Close. Or use Tool Bar Iso 1 View icon.

In the Element Properties form set Action as Show, in Existing Properties select Material Name, and in Display Method select Scalar Plot. Select Groups as hybrid_fem and select Apply. The model should now appear as on the front panel of the exercise.

7. Quit MSC/PATRAN

To stop MSC/PATRAN select File on the Menu Bar and select Quit from the drop-down menu.