**Fabrication Techniques for Mems - Based Sensors: Clinical Perspective**

**Prof. Hardik J Pandya**
**Department of Electronic Systems Engineering**
**Indian Institute of Science, Bangalore**

**Lecture – 55**
**Simulation: Electro- Thermo- Mechanical Properties of Micro-heater using COMSOL Multiphysics contd.**

Hi. welcome to this module. This module is in continuation with the last module where we have seen how to use COMSOL Multiphysics as a simulation tool before we go for fabricating a device.

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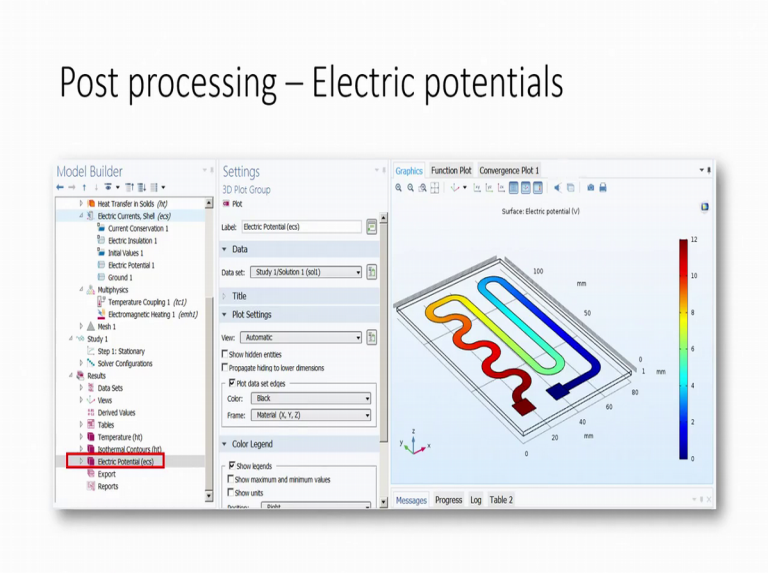


Now, we have taken an example of a heater where we have seen how to understand the electrical potential or the temperature, right when we apply a certain voltage to the pad.

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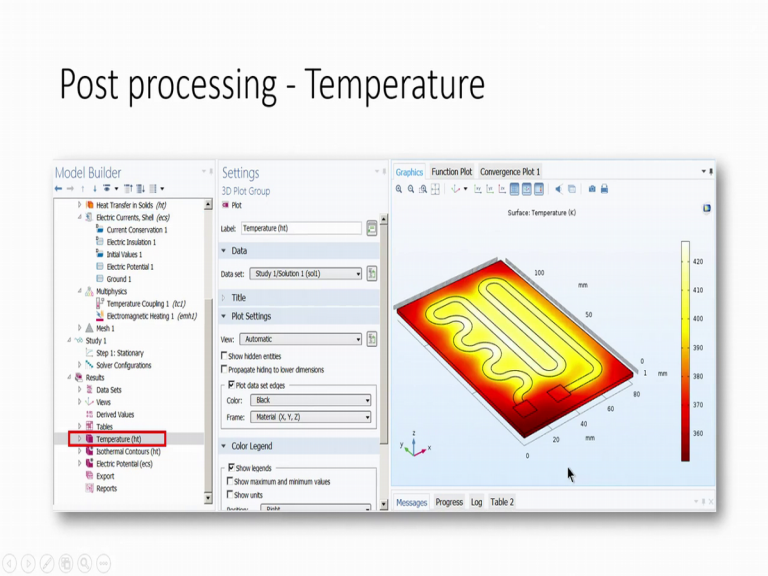


And how we can see like the material, what how we can select the substrate and then how can we perform the basic simulations ok. So, what we have seen in last module is the isotherm temperature, there is a heating and then we have seen the electrical potential that how if I apply 12 volts, how it is varying across the resistor.

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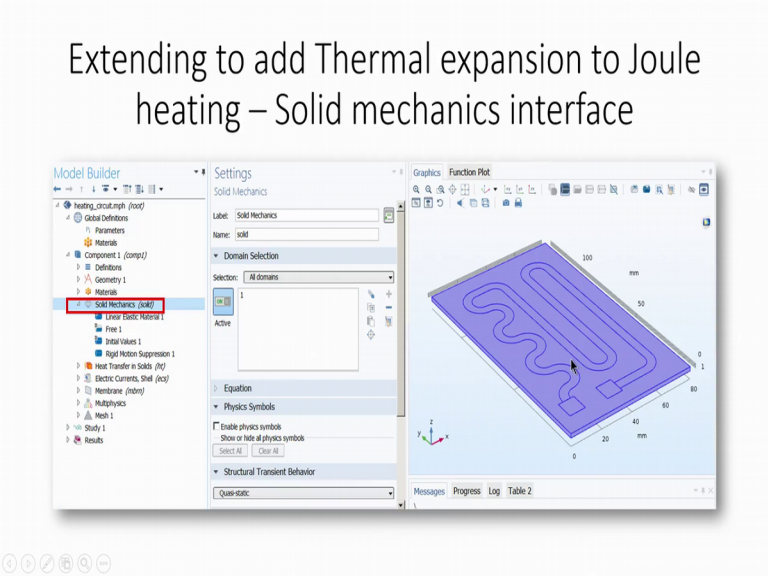

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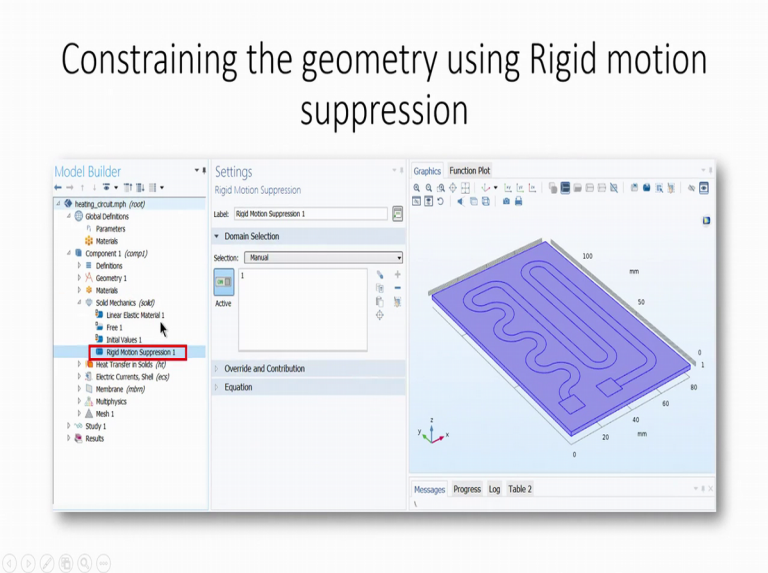


Now, this module let us see further so, further we can see the solid mechanics where we need to understand what is a suppression or rigid motion suppression on the chip.

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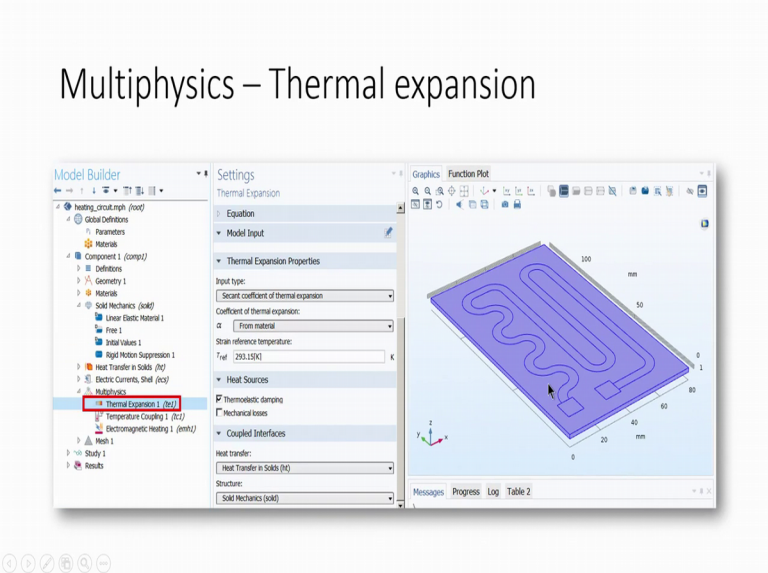


Then, we need to see what is the thermal expansion? So, you can see here the thermal expansion properties we can select for the materials. So, coefficient of thermal expansion material the strain reference temperature is about 293.15. For the selected material, there is a thermoelastic imaging and damping for this particular material and the coupled interfaces for this particular subset is heat transfer in solids and solid mechanics.

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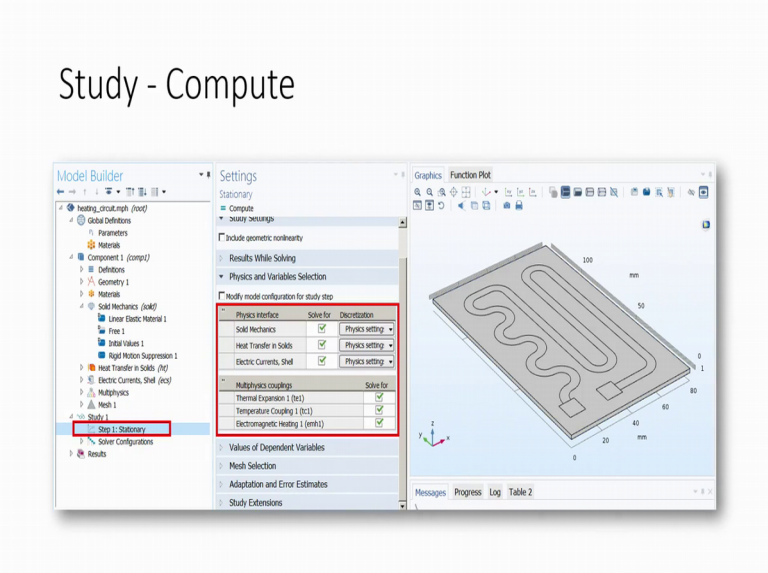


Followed by if I want to go for a stationary then I can select soil mechanics, heat transfer, electrical current and the multiple physics couplings would be thermal expansion, temperature coupling and electromagnetic heating. So, combining all this things together I can understand what is the stress across the film?

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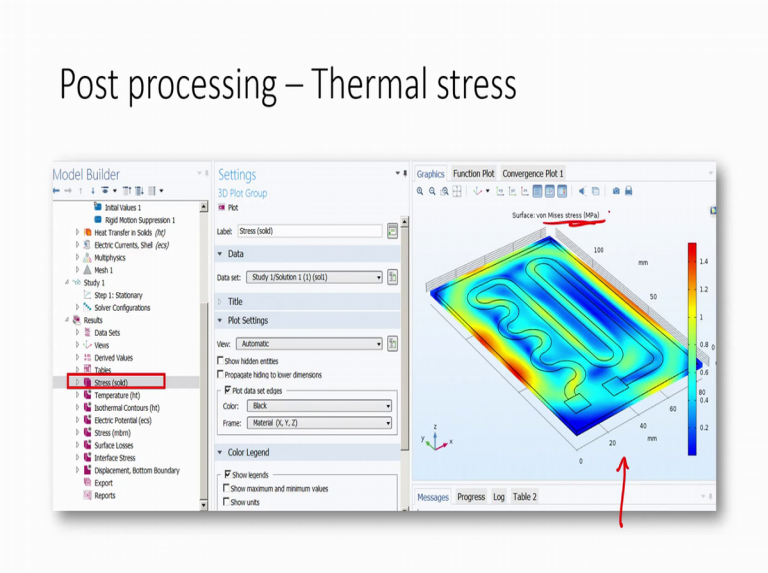


So, this is very important because what we have seen is the heating and what we have seen is the electrical potential. Now, I want to know because of the heating of the chip, what is the stress across the resistor. And you as you see the stress across the resistor as

you move along would be different based on the thermal expansion. And this is a plot that you can see here where the stress at the end of the chip is extremely less compared to the compare to the heating substrates and this is stresses because of the extension this here as well as on this particular area.

Now, this is about 0.8 compare to the almost 0.1 or 0 stress at the edge of the chip. Now, there cannot be 0, there will always be some amount of micro stress and this stress is given in mega Pascal. So, for the current is not really given in mega Pascal the one that we are showing here is somewhere in the mega Pascal range.

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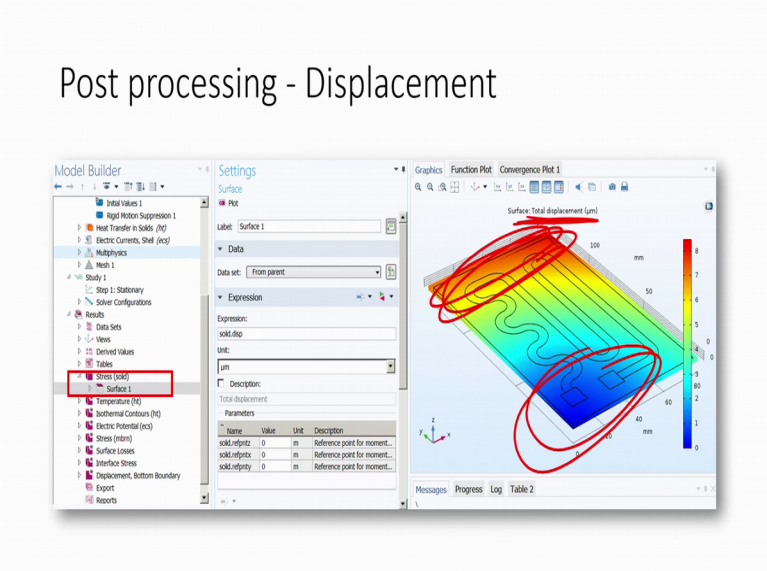


So, other than that, you can also see the stress on the solid surface. So, surface 1 you want to see the expression, then you can see the stress that we have seen here right. Now, if I am showing you the stress, then because of the heating I am I also looking at some displacement.

Now, this is a very interesting because when you heat up, there is a micrometer of displacement. You can see here total displacement of few micrometer because of the expansion of the material and then you can see about 8 micrometer somewhere around here there, right. And it is extremely small at the contact pads and that is again due to the thermal expansion of the material when you heat the material at very high temperature, there will be slight change in the displacement. So, what you can see is not only stress,

not only temperature, not only electrical potential, but also the displacement for the given heater.

So, this we have taken an example of a heater, but we can use a different example like a strain gauge, we can use a example like a pressure sensor, we can use example like microfluidic system and lot of other devices. So, almost all the devices which are micro fabricated and which we have seen in the in this particular course, you can perform simulations right. So, just to go through quickly about how to do COMSOL how to use COMSOL multiphysics? Let us see once again a quick review of what how we can use this particular tool.

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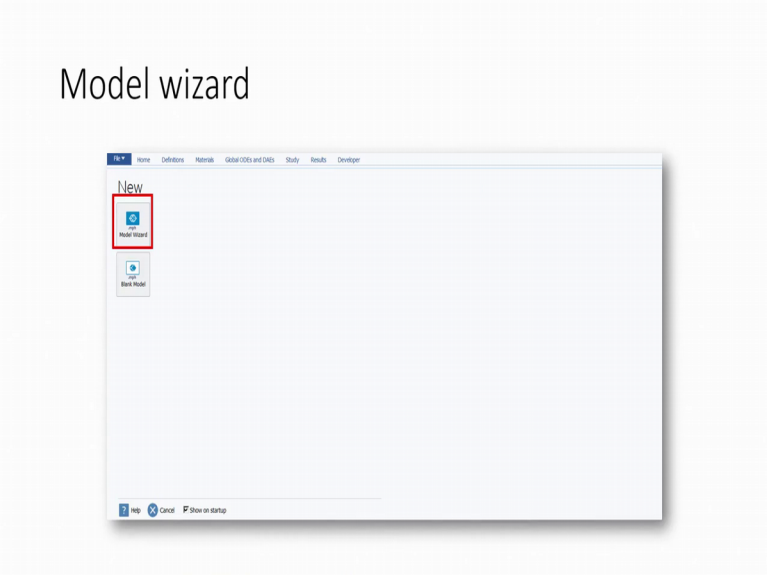


The you start with a the GUI, open a new model wizard, select the space dimension which is 3 D.

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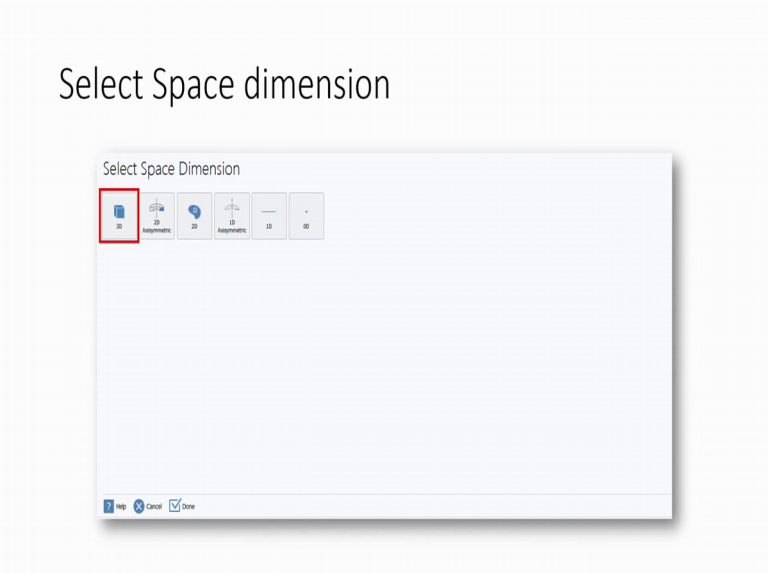


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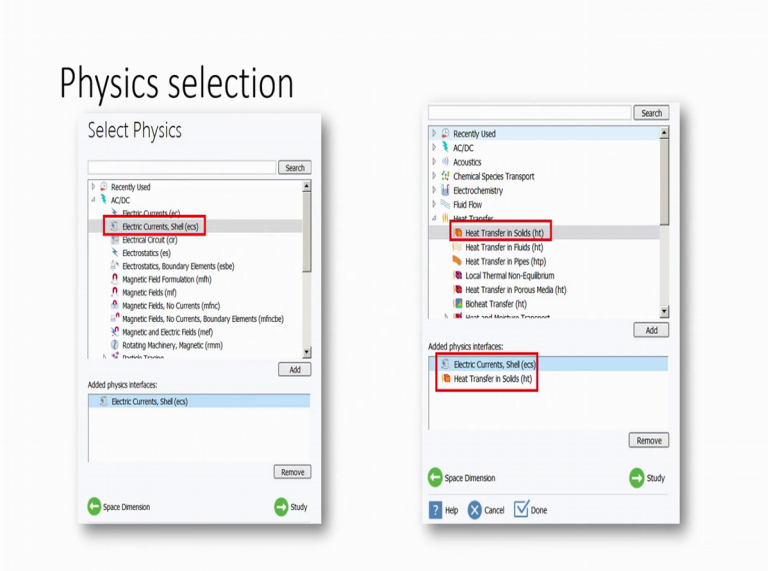


Then, you go for electrical currents and the heat transfer, there will be the physics that you have selected because we are using heater that is why you have selected the heat transfer. We have to apply a voltage that is why we have select a electrical currents.

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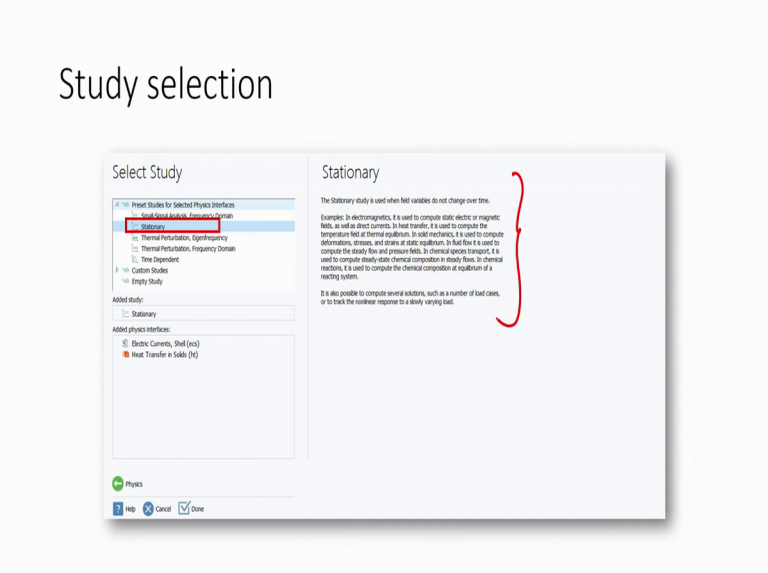


Then, we go for the stationary where we have understood why we have to select a stationary.

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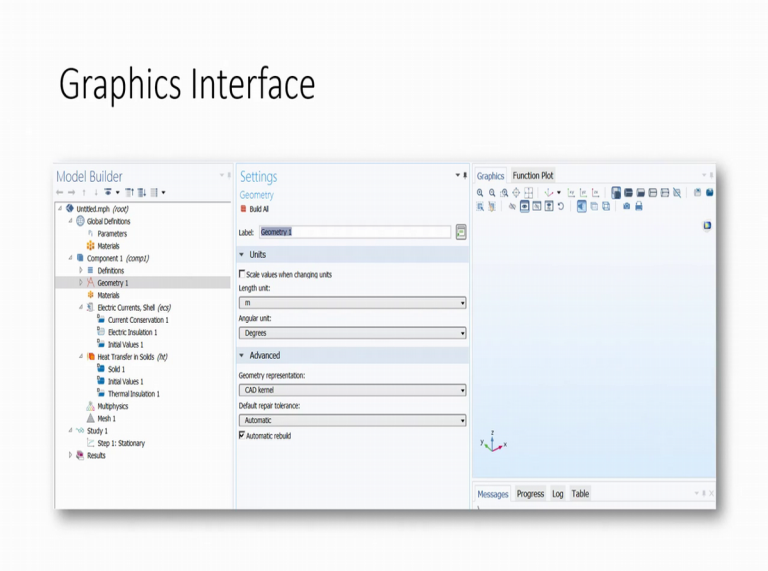


And then, you have to go for the length of the heater, the angular degree what is a model. This is geometry you create a geometry of the heater.

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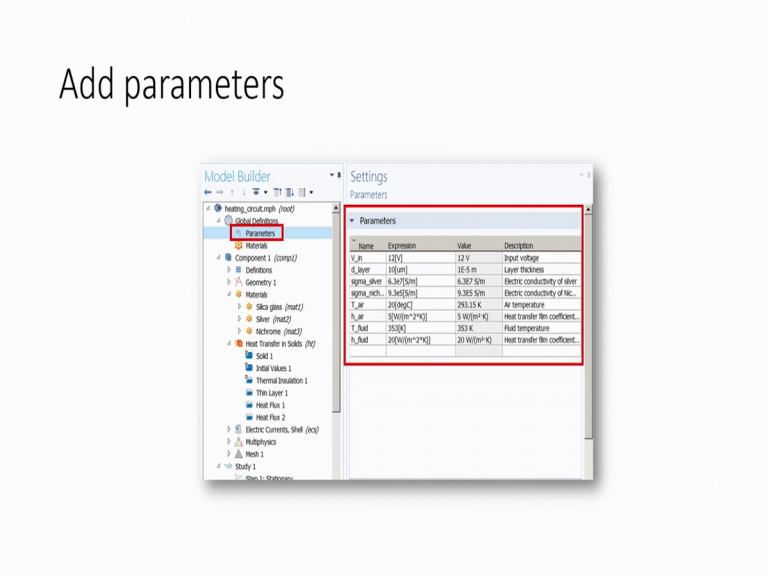


And then, you apply the parameter what will be the parameter that you are applying voltage, thickness, conductivity of silver. Because, you know what is the conductivity of the contact pair, conductivity of the nichrome and then you have to understand, what is the temperature of the room what is a heated air, what is a fluid heat temperature and what is the heat transfer coefficient?

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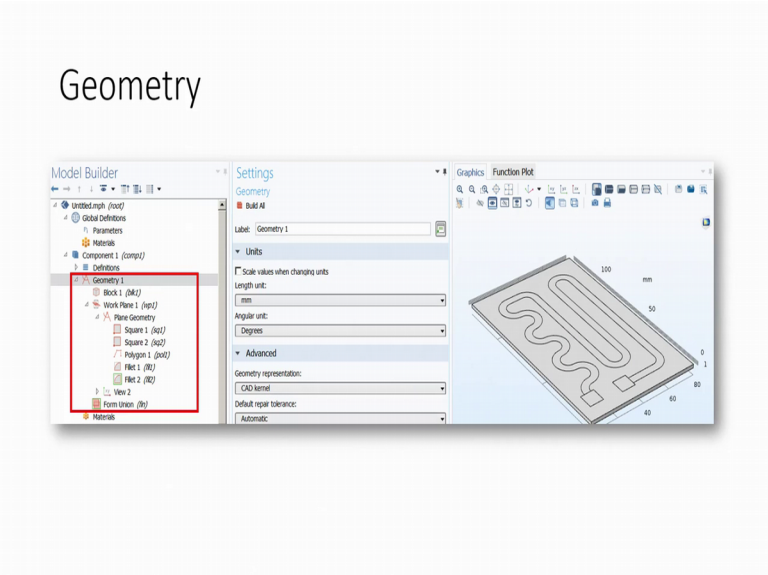


And once you select the parameter, you can always select the length. So, this is length right, you can say length is in millimeter, you can also select micrometer, you can select

centimeter the degrees and then you have square 1, square 2 and filet 1, filet 2. This is work plane or plane geometry.

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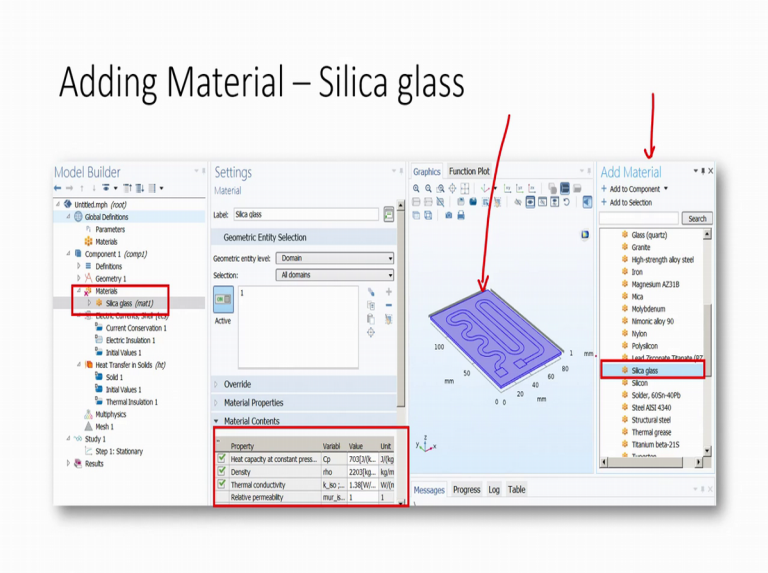


Now, you select the area when you say that first you select is the material on which you are going to fabricate a heater that is your silica or glass or silica glass is same thing. And then you know that when you select the material from this list right, then you will understand that for a given material what are the properties.

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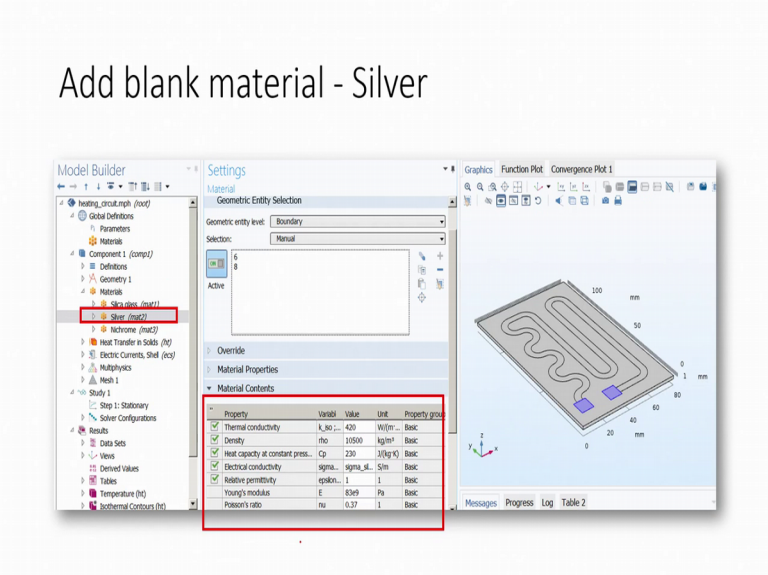

Then, you select the contact pads, the material for the contact pad is silver, you can again see the properties of the silver.

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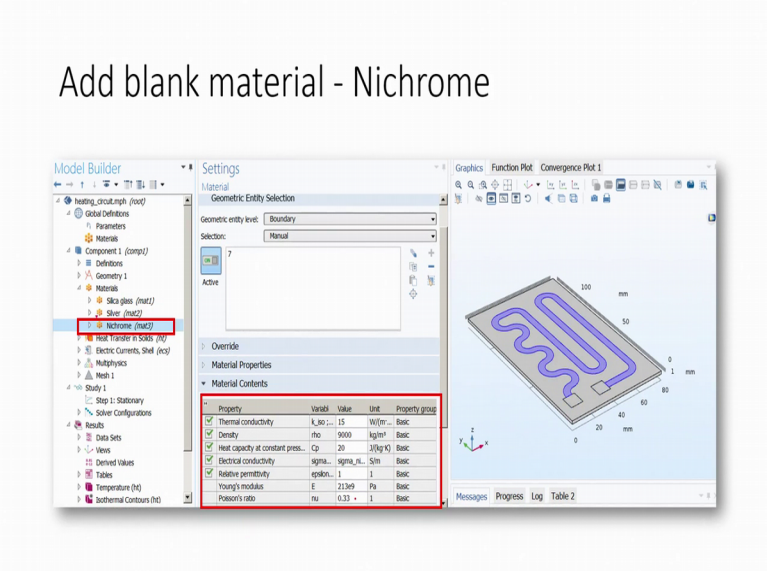


You select the material for the heater which is your nichrome. You can see the properties of the nichrome which is thermal conductivity, density, heat capacity, electrical conductivity, relative permittivity and of course, you have Young's modulus and Poisson's ratio.

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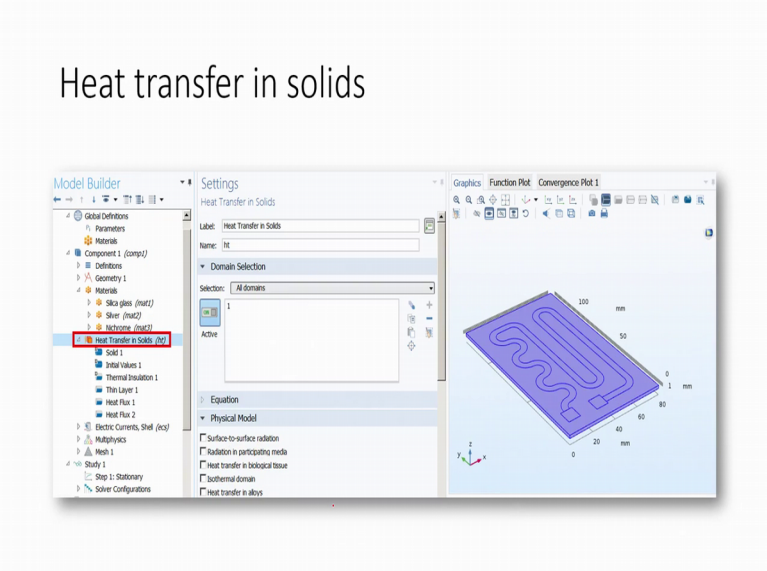

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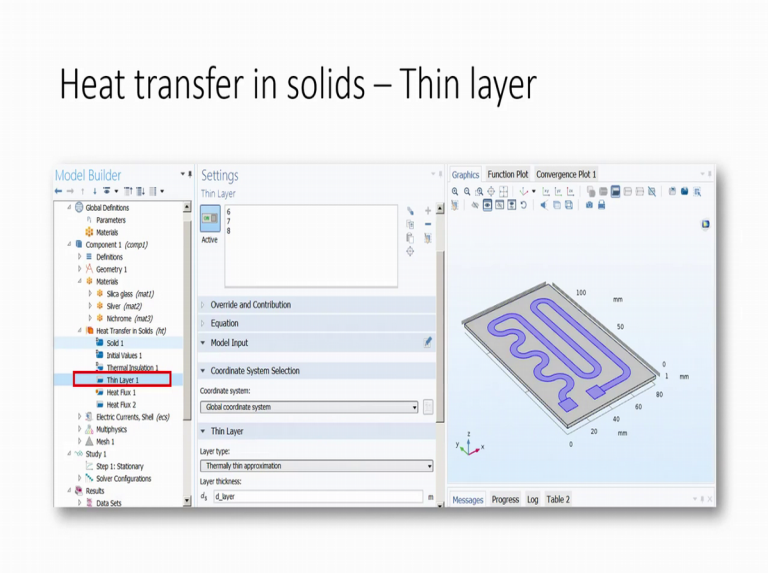


Then, you see we select heat transfer in solids then, you select a thin layer and then, you go for the heat flux.

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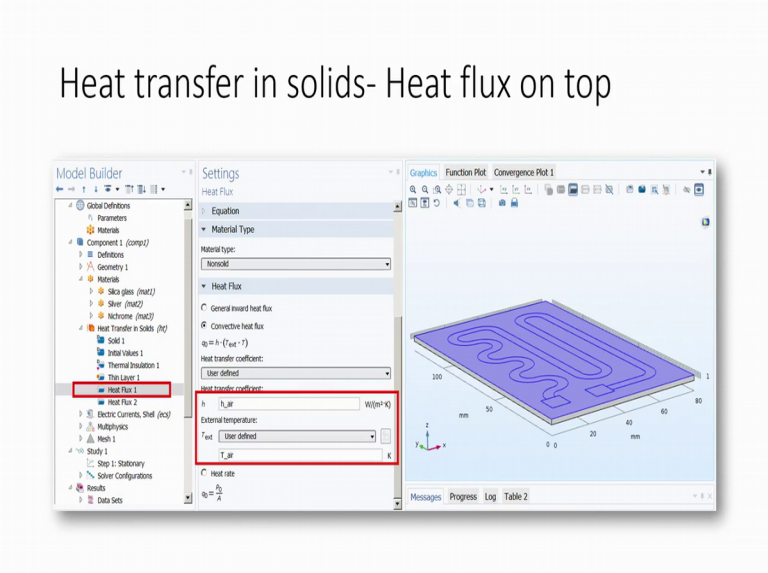


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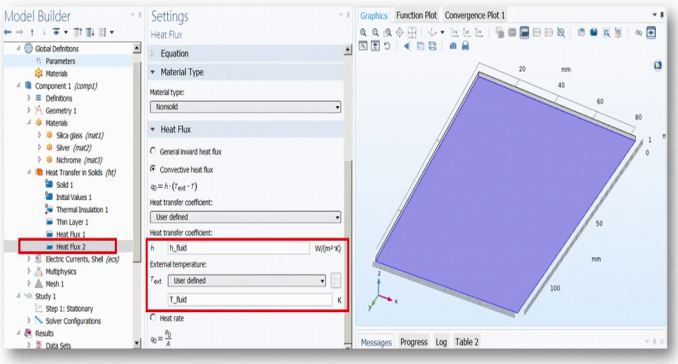
## Heat transfer in solid – Heat flux on bottom

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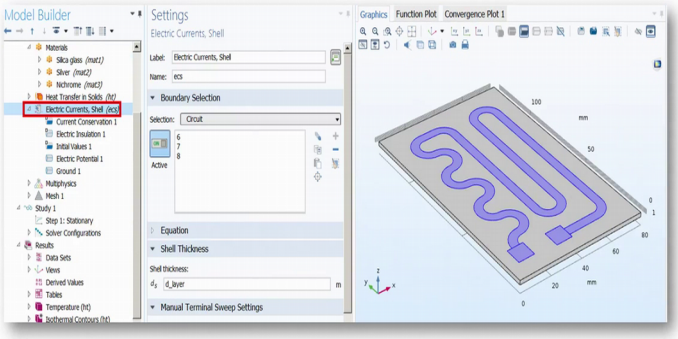
## Electric current, shells



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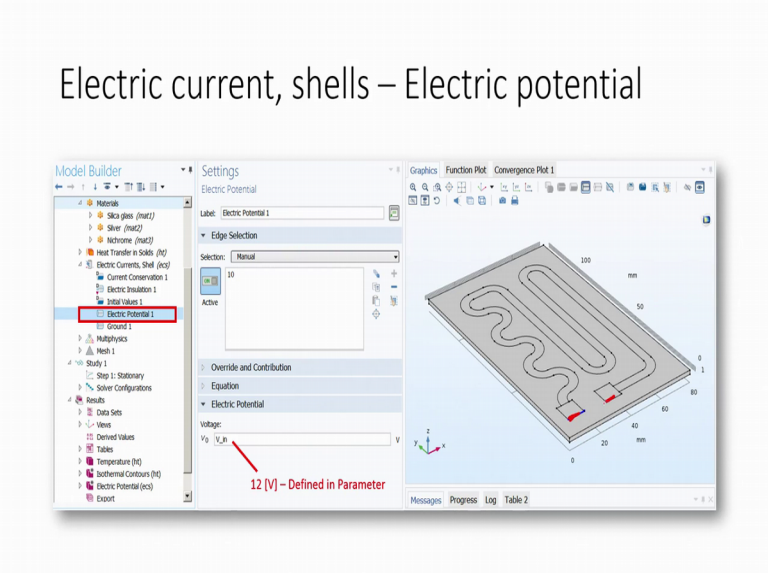


And, heat flux to one front and back side. Then, you go for the electrical potential where you are applying. So, you are applying between this terminal and this terminal so, you are applying 12 volts here ground here.

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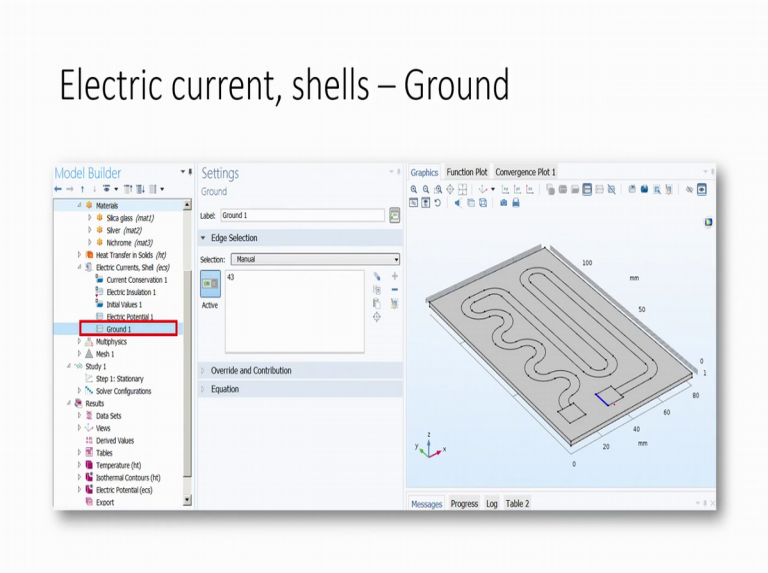

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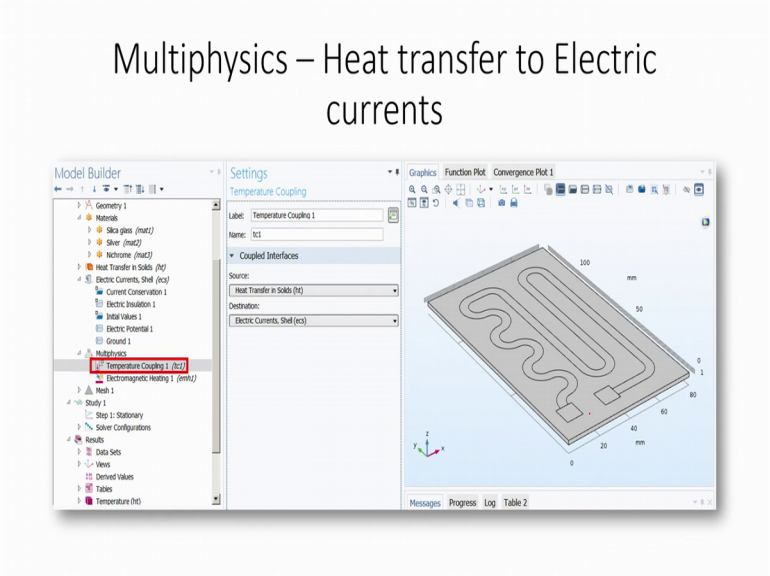


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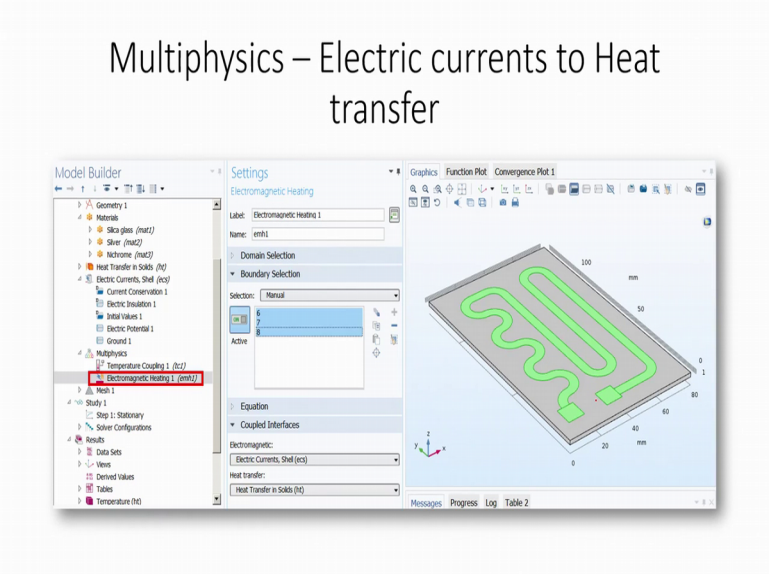

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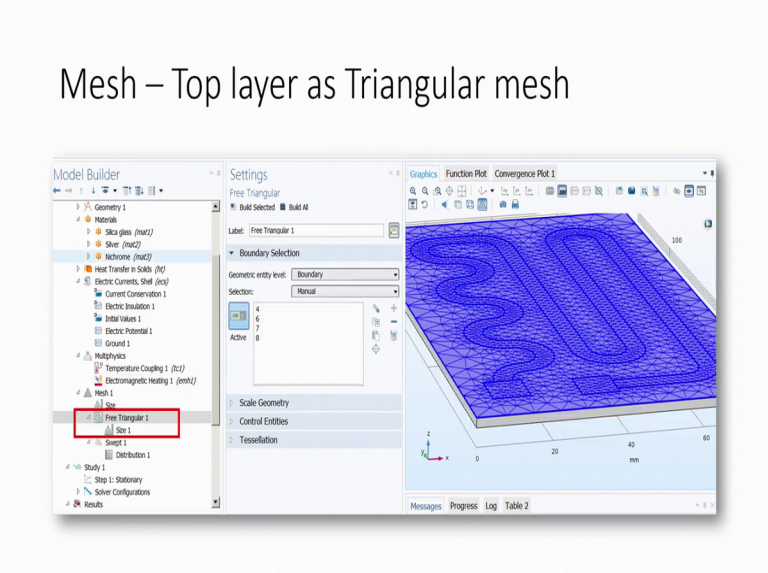


And then, you go for the temperature coupling electromagnetic heating followed by the meshing so, you are creating a mesh, top layer is a triangular mesh, you have swept mesh, the top meshing layer.

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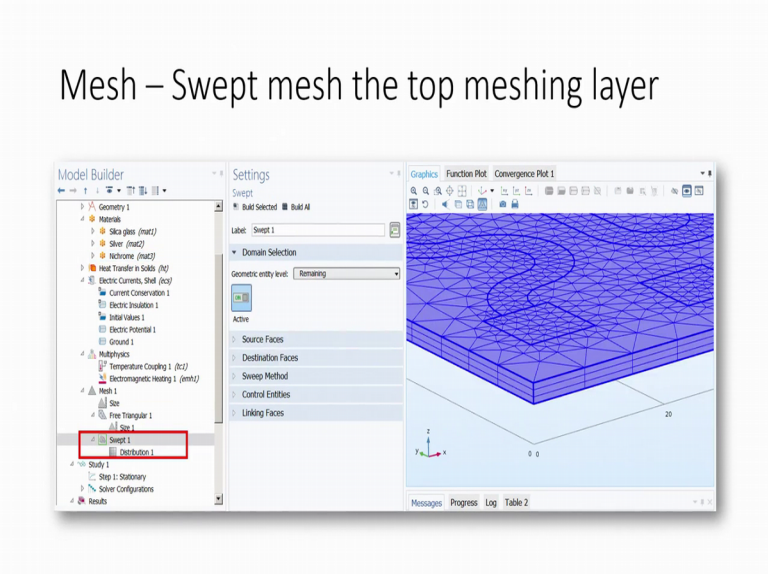

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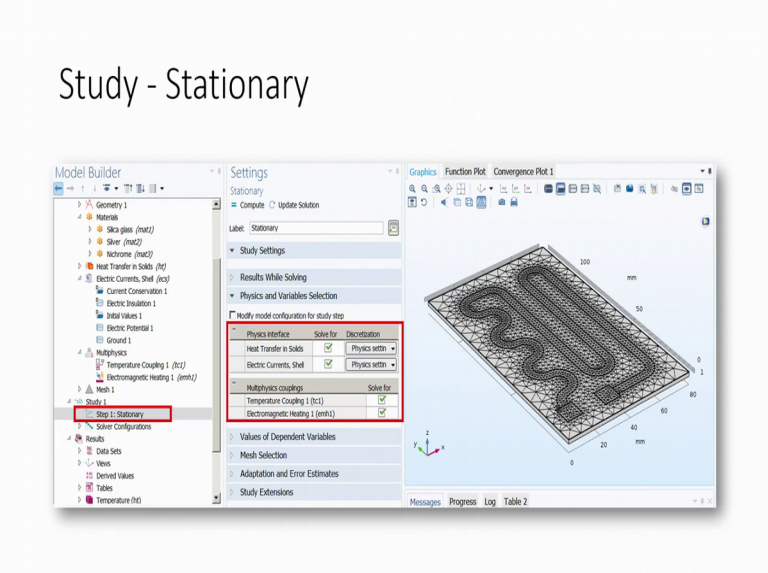


After you swept this mesh, then what is the next term, you have to select the heat transfer in solids, the temperature, electromagnetic heating. You select the temperature, you will see the profile, you select the electrical potential and you see the profile that how the electrical potential changing followed by the solid mechanics. Where you are looking at the region motion suppression, you are looking at the thermal expansion, you are looking at the stationary fields and you are also looking at the stress as well as the displacement.

So, this is how you can use the heater as an example for COMSOL multiphysics. Like I said that most of the devices that we have discussed in our course, you can use those for you use this system to simulate those devices. Again, if you are stuck with any problem in using the COMSOL multiphysics, please get back to us and we will help you out through the forum.

This is a just a quick example because of the limited amount of slot available for the completion of this course. I could not take more than one particular example; however, we will be talking about simulation tools in detail in the next course in the coming semester. So, till then, I wish you all the best for your term exam and if you have any doubt do contact me, we will be very happy to help you out with your doubt. This COMSOL multiphysics like I said is only one of many available simulation tools, right but these are all simulation tools used for microsensors transducers, original MEMS or microfluidic kind of devices ok.

So, that will be end for this particular module and I will get back to you if you have any doubts I have already given my email ID, you already have email ID. If it is really important and again I am repeating this thing as I have done in my online slot course slot that if you pass by IISC and if you want to want to discuss anything that you have come up with a novel idea or you are stuck with anything that you want to discuss one on one right, feel free to send me a email and I will be I will get back to you.

If you are traveling here for any reason, if you want to stop by and visit my lab you are welcome to visit my laboratory as well. The having said that I wish you all the luck for your this course and many more such courses which you will be learning through this beautiful NPTEL platform.

Till then, you take care, have fun, bye.