Case Study 3

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This case study is about a silicon chip surrounded by a block of epoxy at an initial temperature of 150 degrees Celsius cooling down to 22 degrees Celsius and finding the maximum principal stress due to the difference in thermal expansion coefficients.

Some assumptions made in the analysis are uniform cooling, symmetries are modeled as frictionless supports, no yielding or compression in the epoxy or silicon.

For the Finite Element modeling, symmetry was found in the part and that made the part 1/8th the original size, simplifying the analysis. The model was created in Siemen's NX and exported as an IGES file over to Ansys Workbench. In Ansys, I created a static structural analysis, and two new materials labeled Epoxy and Silicon. I then gave both an Isotropic secant coefficient of thermal expansion and isotropic elasticity and entered in their given values. After that, I imported the IGES file, generated it and made sure it was successful. After that, I entered a starting environment temperature of 150 degrees Celsius, set up the frictionless supports on the walls where the symmetries were made, and added a thermal condition to the 2 entire bodies at 22 degrees Celsius. I then solved for the maximum principal stress in the epoxy, the silicon chip, and both together.

The results I found was the epoxy was under a maximum tensile stress of about 50 MPa (Figure 1) and from the internet (www.matweb.com) I found an average tensile yielding strength of 563 MPa, meaning the epoxy is safe from yielding. For the silicon chip I found the maximum compressive stress was 103 MPa and tensile stress to be about 22 MPa (Figure 2), While the internet (www.azom.com) said for 100% silicon the compressive strength is about 3200 MPa and it's tensile strength is about 165 MPa. This means the silicon chip is safe from yielding. The third plot (Figure 3) shows the epoxy and silicon chip combined, and the stresses are the same as Figure 1 and 2 combined.

If I were to redesign this, I would choose a material that has the closest thermal expansion coefficient to the silicon chip, reducing the thermal stress to as low as possible. Having that included stress will make the part more susceptible to impacts due to the internal stress of the thermal contraction.

In conclusion, the epoxy and silicon chip are safe from yielding, but due to the large mismatch in thermal expansion coefficients, there is an internal stress in the assembly that will lead to a weaker part. To remedy this, a material with a more similar thermal expansion coefficient to the silicon should be selected to reduce the internal stress from cooling.

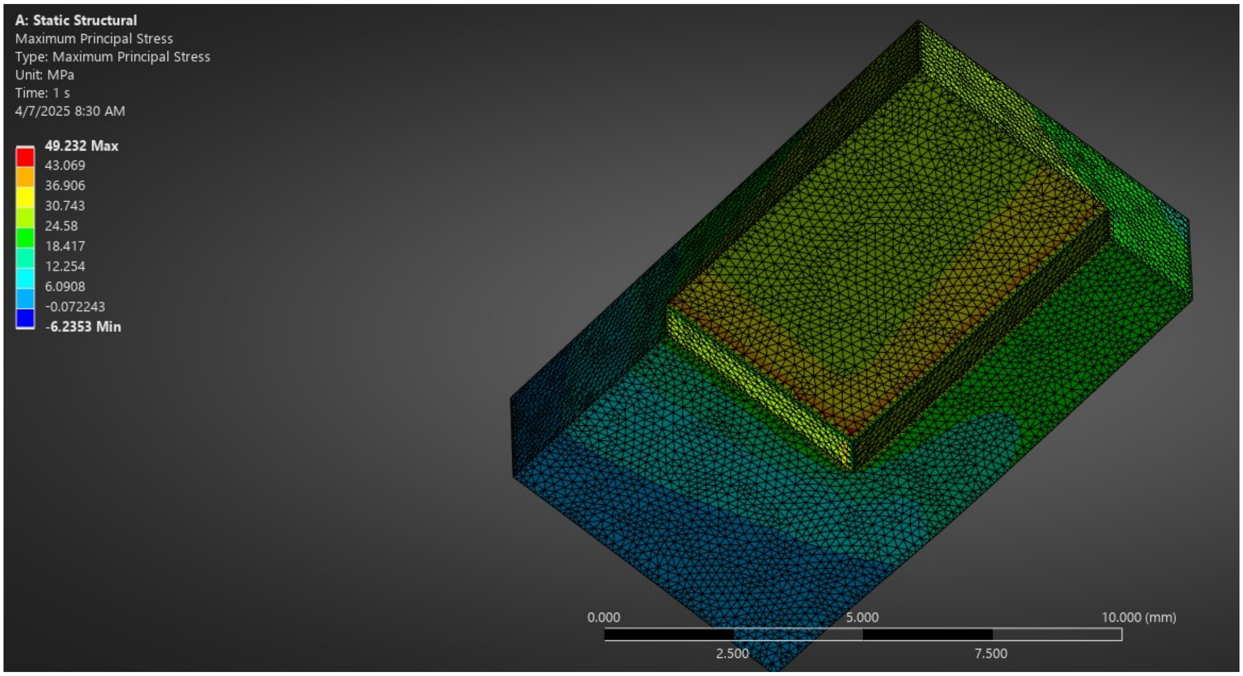

Figure 1: Maximum Principle Stress in Epoxy

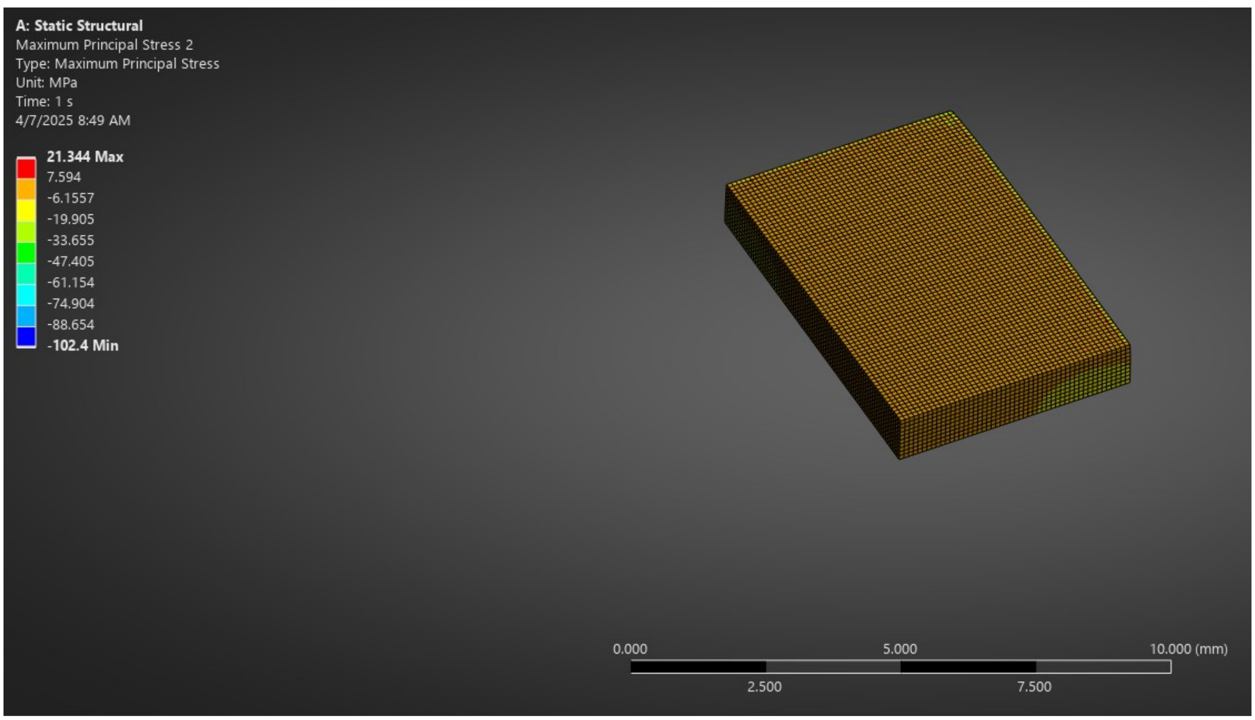

Figure 2: Maximum Principle Stress in Silicon

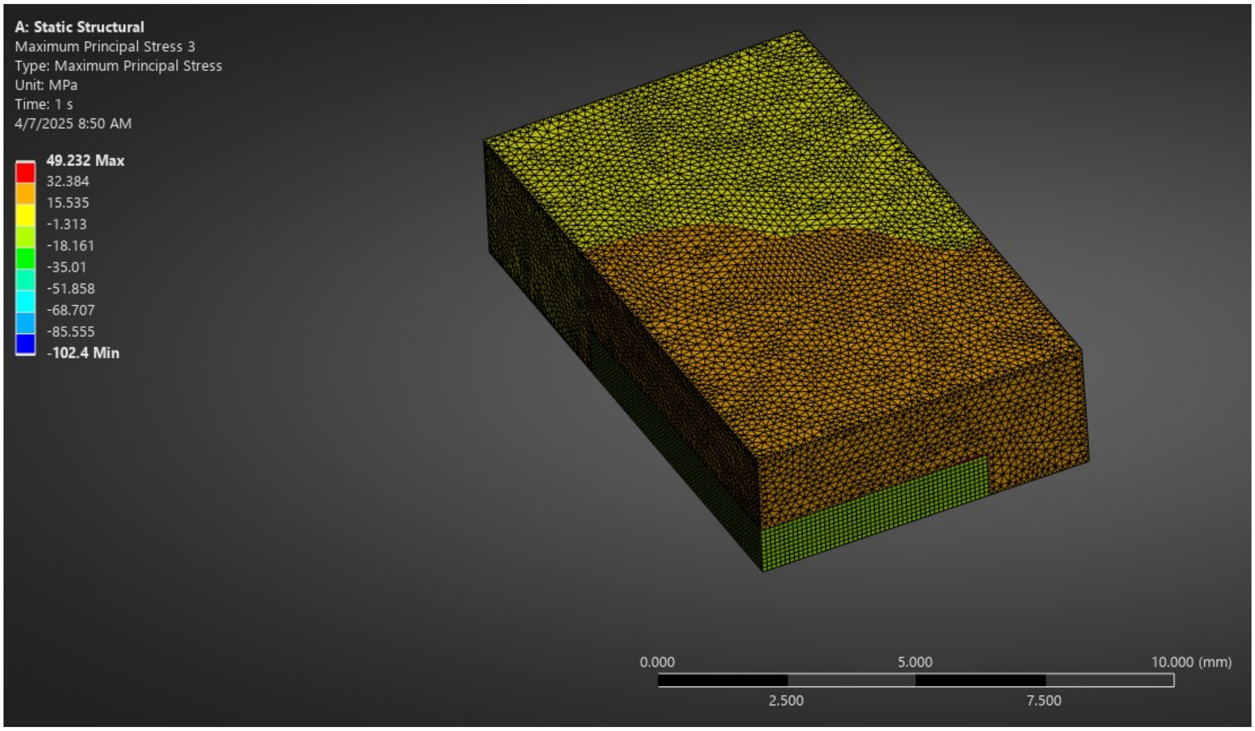

Figure 3: Maximun Principle Stress in Combined Silicon and Epoxy