Basic Mechanical Properties at Multiple Length Scales

Basic mechanical properties of a material can be a function of the material's composition, its atomic structure, its crystallinity, its microstructure, and its macrostructure. In this lab, you will characterize the mechanical properties of your material using a three-point bend test on one of your specimens, which is different from the dog-bone tensile test you conducted in ENES 220. You will also be testing very small specimens of a similar material (pure Aluminum) using a biaxial-microtensile tester so you can understand the differences in obtaining basic mechanical properties using specimens at different size scales.

Part I: Three Point bend testing

In the second portion of the lab, you will mechanically test your specimen in a load frame Three point bend tests can be performed in either displacement control or in load control. In this laboratory, the tests will be performed in displacement control. In displacement control, the deformation is increased at a constant rate. The data obtained will be in the form of a list of loads taken at a sample rate of 5Hz. The displacement is measured and recorded from a micrometer. Simultaneously, strain and displacement data is obtained from the bottom of your specimen using a video extensometer, described in a web link provided.

1. Write a brief description of the test apparatus, the shape of the samples, and the particular materials used.
2. Convert your load and displacement to stress and strain by reducing the data according to the three point bend test analysis in the web link provided.
3. Plot the stress-strain curves for your material on the same set of axes.
4. Calculate the elastic modulus, yield stress, and ultimate stress. Compare these results to typical handbook values. Discuss your observations.

Discuss the following issues in your report:

1. Using the data from the tests, create a true stress-true strain curve for your specimen. Use curve fitting to compute the hardness exponent. Is there a substantial difference in the true stress-true strain compared with before your calculation? What does this mean?

2. How does the strain compare between the video extensometer and that calculated from the video extensometer displacements and the micrometer? If there are differences, what do you think may cause them?

3. Use the ductility measures of percent elongation and percent area reduction to compare the ductility of steel and aluminum. What is the ductility of your material? How might you make it stronger? How might you make it stiffer?

4. According to your results, what are the defect mechanisms in your specimen? On what do you base this conclusion?

5. Note the shape of the fracture surface on the sample. Was it a “cup and cone” type of fracture or a “flat fracture” discussed in the lecture? Was it some other shape? Why does it have this shape?

6. In ENES 220 you saw a dog-bone tensile test. How does this three point bend test compare to that one? Is the data you obtained similar? If not, why do you think that might be the case?

Part II: Biaxial microtensile testing of Small-scale specimens

In the second portion of the lab, you will mechanically test a thin film specimen (25 microns thick) just 1 cm x 1 cm in a microtensile tester. This is a smaller version of your material made of pure aluminum. The test will be conducted in uniaxial tension and biaxial tension with a transverse load of 20 MPa. The strain data has been reduced for you and posted.

1. How does the data from this test compare with your large specimens? How does it compare with the dog-bone tensile test you saw in ENES 220? If there are differences, what might be the reason?
2. Is there a difference between the uniaxial and biaxial tension test data? Based on the deformation mechanism that you learned is responsible for plastic deformation, why or why not would you expect for there to be a difference between the tests (remember Mohr’s circle from ENES 220)?