In-Class Exercise
Phase Diagram for Nitinol
SOLUTIONS

The figure below is a phase diagram for Ti-Ni. This is important in designing nitnol material because you need to ensure that your material is single phase NiTi over the temperatures and compositions you will use the device at.

1.) What are the phases and components?
The components are what make up the axis of the composition (Ni and Ti).
The phases are:

- Liquid
- β(Ti), α(Ti): these are 2 different solid phases (they have different crystal structures). The (Ti) is in parentheses because it indicates it isn't pure, some Ni is dissolved in it.
- (Ni): The (Ni) is in parentheses because it indicates it isn't pure, some Ti is dissolved in it.
- TiNi
- Ti_2Ni
- $TiNi_3$: This is an intermetallic compound that only exists at that exact composition. There is no extra Ni soluble in it so it appears as a straight line on the phase diagram.

2.) Label all of the two phase regions. To do this, you need to look at the single phase regions to the left and right of the unmarked region. See diagram on next page

3.) Find 3 eutectic points, 1 eutectoid point, and 5 congruent transformations.

- Congruent points: these are labeled by green dots on the diagram. This is where a solid transforms to a liquid or a different solid without going through a two phase, transition region.
- Eutectic: these are labeled by pink dots on the diagram. This is where a liquid cools to two different solids without going through a liquid + solid region. The eutectic transformation is L → solid(1) + solid(2)
- Eutectoid: this is marked by a blue dot. The eutectoid transformation is solid(1) → solid(2) + solid(3)

4.) If you have a liquid that is 70 atomic % Ni that is cooled to 1000°C. The light orange lines on the phase diagram mark out this composition and temperature.

a.) What phases are present? TiNi + $TiNi_3$

b.) What is the composition of each phase? To solve this, you need the intercepts of the tie line with each of the single phase composition regions to the left and right. See the dark orange lines on the phase diagram.

TiNi is 54 atomic % Ni, 36 atomic % Ti
$TiNi_3$ is 75 atomic % Ni, 25 atomic % Ti

c.) What is the atomic fraction of each phase? This means the fraction of TiNi and fraction of $TiNi_3$. You solve this with the lever rule and it should add up to 1. It

is worded as “atomic fraction” because the x axis is atomic %. If you used the top x axis (weight %), it would be the weight fraction.

$$w_{TiNi} = \frac{C_{TiNi3} - C_o}{C_{TiNi3} - C_{TiNi}} = \frac{75 - 70at\%}{75 - 54at\%} = 0.24$$

$$w_{TiNi3} = \frac{C_o - C_{TiNi}}{C_{TiNi3} - C_{TiNi}} = \frac{70 - 54at\%}{75 - 54at\%} = 0.76$$

d.) Sketch the microstructure of the sample and label each phase.