

Ph.D. Qualifying Examination

Materials Science

Summer 2023

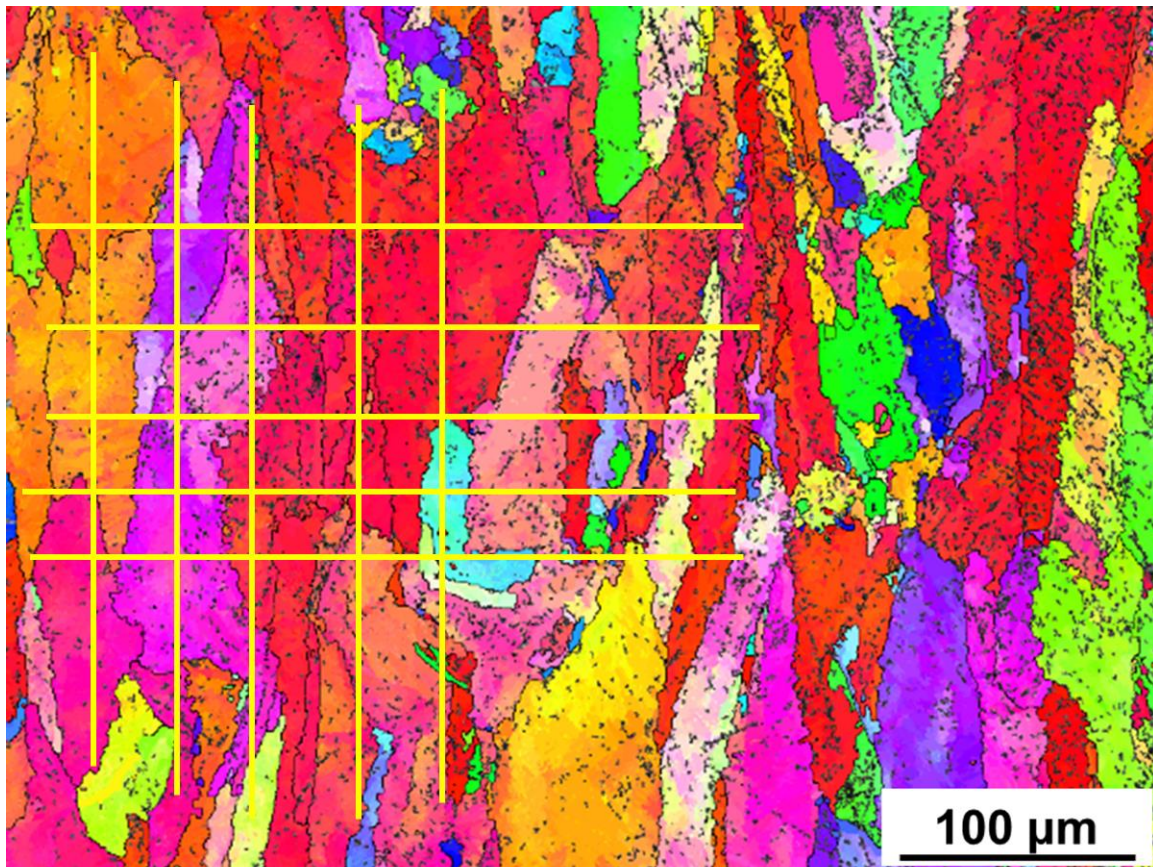
Notes:

- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes.
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

1. Describe how the metallic bonding characteristics differ from ionic and covalent bonding. What characteristic properties do you expect because of the metallic bonding in a material? Give details.

2. Determine the average grain width and length of the following AM-printed titanium alloy microstructure by line intercept method. Length of each yellow line is 126 mm, and the scale bar length measurement is 42 mm. (Hint: Use the formula $\bar{l} = \frac{L_T}{PM}$; in both horizontal and vertical directions to find the width and length of the grains, respectively. $\bar{l}$: Mean intercept length, L_T : Total length of lines (5 x 126 mm), P: total number of grain boundary intersections, M: Magnification. $M = \frac{\text{Length of the scale bar}}{\text{number next to the scale bar}} = \frac{42\text{mm}}{100\mu\text{m}}$)

How does the grain size affect the tensile and fatigue performance of metallic materials? Explain in detail.



3. Discuss three different types of strengthening mechanisms that can be used in metals? Cite the main differences between brittle and ductile fractures.

4. A cylindrical rod of noncold-worked brass having an initial diameter of 6.4 mm is to be cold worked by drawing such that the cross-sectional area is reduced. It is required to have a cold-worked yield strength of at least 345 MPa and a ductility in excess of 20%EL; in addition, a final diameter of 5.1 mm is necessary. Describe the manner in which this procedure may be carried out.

