

1. True & False (15%)

- (a) In general, there is no long range ordering in amorphous materials.
- (b) Superalloy needs ultrafine grains to achieve very high strength at high temperature.
- (c) Graphite is conductive but graphene is insulator.
- (d) Eutectoid point has zero degree of free in binary phase diagram at constant pressure.
- (e) It is harder to cross slip for dislocations in materials with lower stacking fault energy.

2. Steels (20%)

- (a) Please plot Fe-Fe₃C phase diagram. (8%)
- (b) Please define eutectoid point in the phase diagram. (3%)
- (c) Please define martensitic transformation in the phase diagram. (3%)
- (d) Explain how to produce ferrite-martensite dual-phase steel by using Fe-0.2C (in wt. %) alloy. The phase constituents are about 70 wt. % ferrite and 30 wt. %martensite. (6%)

3. Aluminum Alloys (10%)

- (a) What are three major strengthening mechanism in aluminum alloys? (5%)
- (b) What is Orowan mechanism? (3%)
- (c) What is G-P zone? (2%)

4. Materials Applications (10%)

What is Sol-Gel? Please explain the process and its application.

5. Functional Materials (10%)

- (a) List the differences between Si-based and GaN-based semiconductors.(6%)
- (b) List the differences between Si-based and GaN-based solar cells. (4%)

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6. Polymer Science (10%)

The Figure 1 below shows the analysis of differential scanning calorimetry (DSC) measured for polylactic acid (PLA).

(a) Please explain the physical meanings of the following temperature: 57.5 °C, 118.0 °C, and 153.5/158.8 °C. (5%)

(b) Moreover, why is there temperature splitting at 153.5/158.8 °C. (5%)

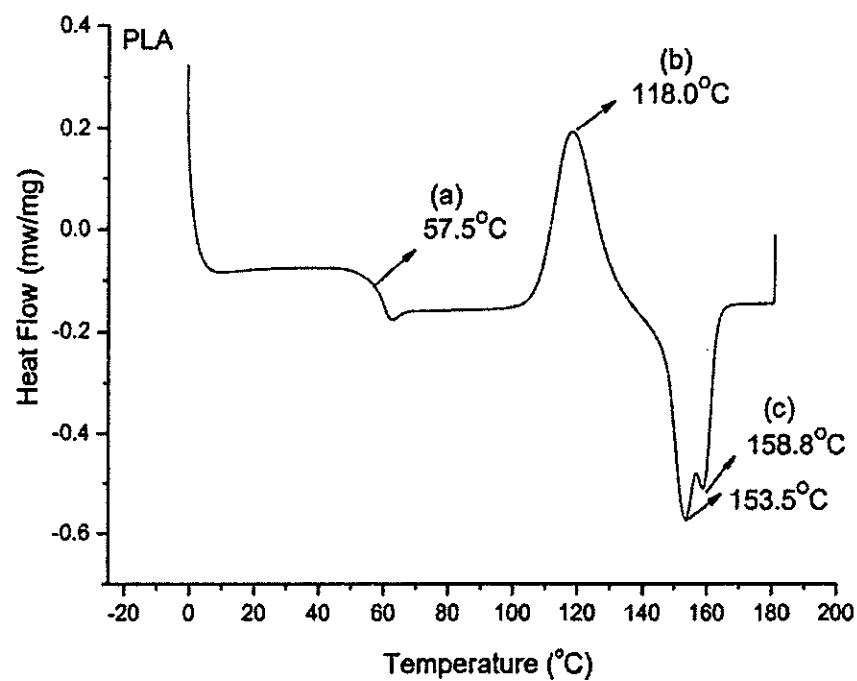


Figure 1 The analysis of differential scanning calorimetry (DSC) measured for polylactic acid (PLA)

7. Energy Materials (5%)

What is Organic-Inorganic Perovskite? Please explain its crystal structure, process, and applications.

8. Characterizations (5%)

Can one precisely determine the chemical composition of CoCrFeMnNi high-entropy alloy by using X-ray energy-dispersive spectrum? Why?

9. Ceramics (15%)

If we consider two spherical grains that are in contact during a sintering process (Figure 2), we see that at the surface of the two grains the radius of curvature is R (convex) while at the bridge connection between the two spheres the radius of curvature is r (concave). The pressure difference between convex and concave surfaces is ΔP .

(a) Please derive ΔP is proportional to $(R+r)/Rr$, and (10%)

(b) Which side in materials can have higher concentration of vacancy, convex or concave? Why? (5%)

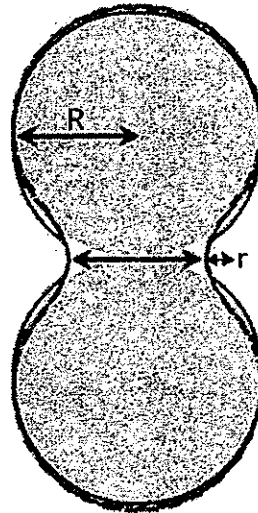


Figure 2 Sintering of two particles with their average radius equal to R .

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