BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B.TECH. **SEMESTER : VI**
BRANCH: PIE/MECH **SESSION : SP/24**

SUBJECT: PE324 SURFACE ENGINEERING AND LASER ADDITIVE MANUFACTURING
TIME: 3 Hours **FULL MARKS: 100**

INSTRUCTIONS:
1. The question paper contains 7 parts.
2. Attempt all questions.
3. Before attempting the question paper, be sure that you have got the correct question paper.
4. Read the instructions in each part carefully and answer accordingly.

Part I (Fundamental) CO1 BL2,3 M1

Instruction: Choose the APPROPRIATE option from the following (1 X 10 = 10 marks):

1. A metallic solid is mostly (a)crystalline, (b) conducting, (c) possessing high density, and (d) easily deformable – please explain why in just one line.
2. Ceramic solids usually possess LOWER DENSITY than metals - please explain why in just one line.
3. Thermoplastic polymers usually possess low creep strength - please explain why in just one line.
4. Any crystalline solid, even if it possesses a simple cubic or most symmetric structure is never fully ISOTROPIC - please explain why in just one line.
5. The atomic packing density of any crystalline solid can at best be 74% and never 100% - please explain why in just one line.
6. Unlike metals, dislocations are NOT useful to explain the deformation behavior of crystalline ionic solids - please explain why in just one line.
7. The grain and phase boundary, other than orientation, differ in one other property - please explain why in just one line.
8. All solids of finite size will have surface energy - please explain why in just one line.
9. Something typical in crystalline solid is completely absent in an amorphous solid - please explain why in just one line
10. Hexagonal close-packed (HCP) structure is not included in the list of 14 Bravais lattices though a large number of metals like magnesium and zinc possess HCP structure - please explain why in just one line.

Part II (Definition) CO2,3 BL1,2 M2,3

Instructions: Select the RIGHT word or phrase from the options given in brackets for each statement to fill in the blank(1 X 10 = 10 marks):

11. Mechanical interaction between two similar or dissimilar solid surfaces is called _____

12. A possible surface engineering method that can change the surface composition without affecting or changing any property, structure, or composition of the underlying bulk solid is _____

13. Name a typical property that is ONLY surface dependent but NOT dependent on the bulk of the solid _____

14. Name a representative property that is NOT a surface but a BULK-dependent property _____

15. The MOST LIKELY mode of DAMAGE encountered in the nozzle of a high-pressure powder jet spray unit is _____

16. The MOST appropriate instrument for monitoring isothermal oxidation kinetics in the air of a metallic sample can be _____

17. Transient micro-welding followed by instant de-cohesion is characteristic of the damage called _____ wear

18. Surface or corners of an acid-leaching plant containing hydrofluoric acid are likely to suffer _____ corrosion

19. Besides improving hardness and wear resistance, a COMMON BENEFIT obtained by different surface engineering methods like Glass Tempering, Ultrasonic Peening, Induction Hardening, and Ion implantation is the development of _____ on the surface

20. In induction hardening of steel, the depth of the hardened zone varies _____ with induced frequency

Part III (Objective) **CO2,3 BL1,4 M3**

Instruction: Provide only a ONE-WORD answer to the following(1 X 10 = 10 marks):

21. Name the phase transformation responsible for developing high hardness, wear resistance, and residual compressive strength after induction hardening of a steel shaft
22. Name the principal reason for the development of a combination of very high hardness and wear and corrosion resistance after nitriding of steel.
23. Name the element that is responsible for inducing good weathering and scratch and aqueous corrosion resistance of steel sheets after galvanizing
24. Name a typical surface coating technique that involves the delivery of coating powders at supersonic velocity
25. Name any surface engineering method for non-ferrous metals and alloys based on thermally activated diffusion of substitutional elements
26. Name a possible method to improve the surface hardness of an austenitic stainless steel tool
27. Name any two elements that are ideal for improving the oxidation resistance of metals at elevated temperature
28. Name the property that is improved by conversion coating of steel before galvanizing, painting, or any other surface coating
29. Name the reason why nickel is added to austenitic stainless steel though chromium is the principal reason for stainlessness
30. Name an element that can provide cathodic protection to steel components

Part IV (Critical comparison) **CO1,3 BL4 M1,3,4**

Instruction: State at least one major difference only in one line between the following pairs in terms of product, process, microstructure, or properties (2 X 10 = 20 marks):

31. Carburizing and calorizing
32. Ferrite and martensite
33. Covalent and ionic bond
34. Thermoelastic and thermoplastic polymers
35. Grinding and polishing
36. Physical and chemical vapor deposition
37. Substitutional and interstitial atoms
38. Electrochemical and electrodeposition processes
39. Hardness and compressive strength

40. Beam line ion implantation and plasma immersion ion implantation

Part V (Objective reasoning) CO2,5 BL2,3,4 M4,5

Instruction: Write a very BRIEF answer to the following (2 x 10 = 20 marks)

41. State the MOST important reason why a laser beam is more suited to surface engineering than an electron beam
42. Briefly explain why an electron beam is BETTER SUITED for welding reactive metals like titanium alloy than a laser beam
43. Name the TWO most important (independent) process parameters that can enable almost all possible laser-assisted surface engineering and material processing
44. State the three most attractive advantages that make laser-assisted additive manufacturing the future direction of the hardware sector
45. What are the two most widely practiced approaches to laser additive manufacturing?
46. Laser additive manufacturing is practically independent of the number and complexity of the final product – offer your brief justification for this statement
47. State the NAME and PRINCIPLE of a single surface engineering method that can produce significant grain refinement only up to limited depth on to the surface of a metallic component without changing the composition
48. Name the SURFACE DEGRADATION process that involves counter-ionic transport of both anions and cations
49. Laser-assisted additive manufacturing of ceramic material is certainly not as successful as that with metallic or polymeric materials – identify a few major reasons in support of this observation
50. State the main reasons why an additively manufactured metallic component is likely to be less reliable than that made by conventional cast or wrought product

Part VI (Schematic answering) CO1,3 BL3,4 M1,2,3

Instruction: Draw a schematic (not to scale) diagram with proper labeling of the following product, process, or principle (2 X 5 = 10 marks):

51. Solute concentration profile as a function of depth from the surface after carburizing and sputtering
52. Surface microstructure of a steel component after laser surface hardening and annealing
53. Typical thermal cycles (temperature versus time) adopted for induction hardening and nitriding of steel (with respect to AC_3 and AC_1 temperatures)
54. Differentiate between the solubility limits in binary isomorphous and peritectic phase diagrams
55. Differentiate between the phase aggregates before and after eutectic vis-à-vis eutectoid transformations (as seen in the respective schematic binary phase diagrams)

Part VII (Process design) CO3,4 BL5,6 M3,4,5

Instruction: Write brief answers to the following with a schematic diagram, related microstructure, flow sheet, or process details, wherever possible (4X 5 = 20 marks):

56. A 20 cm diameter connecting rod made of low alloy steel of a heavy truck needs improvement in fatigue strength – propose a suitable method with a process sketch, and state the process parameters, mechanism of improvement, and its novelty.

57. The wear resistance of a precision gear made of bearing steel needs improvement. Suggest a suitable technique to achieve that with a process diagram, and state the parameters, conditions, thermal cycle, microstructure along depth, and justification.

58. An imitation jewellery of Al-bronze needs a shining yellow or golden coating. Propose a suitable method (name) to create such a deposit of 20 micro-m thickness and state the conditions, parameters, ingredients, equipment, and utility of the process.

59. Superalloy-based gas turbine blades need protection against high-temperature degradation. Select an appropriate technique to counter the threat with mentions about the process details, ingredients and principles involved, conditions, thermal cycle, and advantages of this process.

60. Propose a suitable additive manufacturing routine with a sketch, materials, process parameters, conditions, possible limitations, and main advantages to fabricate customized prosthetic implants based on metallic alloy with compositional gradation.

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