

**22MPP561**  
**Nanomaterials and Composites**

Semester 1 2022/23

Online Short-window Exam paper

This is an online short-window examination, meaning you have a total of **2 hours plus an additional 30 minutes** to complete and submit this paper. The additional 30 minutes are for downloading the paper and uploading your answers when you have finished. If you have extra time or rest breaks as part of a Reasonable Adjustment, you will have further additional time as indicated on your exam timetable.

**It is your responsibility to submit your work by the deadline for this examination. You must make sure you leave yourself enough time to do so.**

**It is also your responsibility to check that you have submitted the correct file.**

Exam Help

If you are experiencing difficulties in accessing or uploading files during the exam period, you should contact the Exam Helpline. For urgent queries please call **01509 222900**.

For other queries email [examhelp@lboro.ac.uk](mailto:examhelp@lboro.ac.uk)

You may handwrite and/or word process your answers, as you see fit.

You may use a calculator for this exam.

Answer **THREE** questions.

1. (a) Explain why surface/facet tailoring of nanosized photocatalysts could lead to improved photocatalytic efficiency. [7 marks]
- (b) Discuss how nanosizing of active materials could impact the electrochemical and mechanical performance of liquid electrolyte Li-ion batteries. Your answer should include both advantages and disadvantages of this approach in batteries. [7 marks]
- (c) An all-solid-state battery has been manufactured with a nanostructured-cathode combined with micro-sized solid electrolyte particles. Briefly explain how the Li-ion movement could be impacted at the interface of cathode and solid electrolyte if the solid electrolyte particles are reduced to nanosized particles. [6 marks]

2. (a) Explain why ceramic matrix nanocomposites are generally more difficult to fabricate as compared to monolithic ceramics. [5 marks]
- (b) The microstructure of a SiNC fibre in SiC ceramic matrix composite is shown in Figure Q2 below. Discuss TWO reinforcement toughening mechanisms that could be achieved using this microstructure, giving a brief explanation of each. [5 marks]

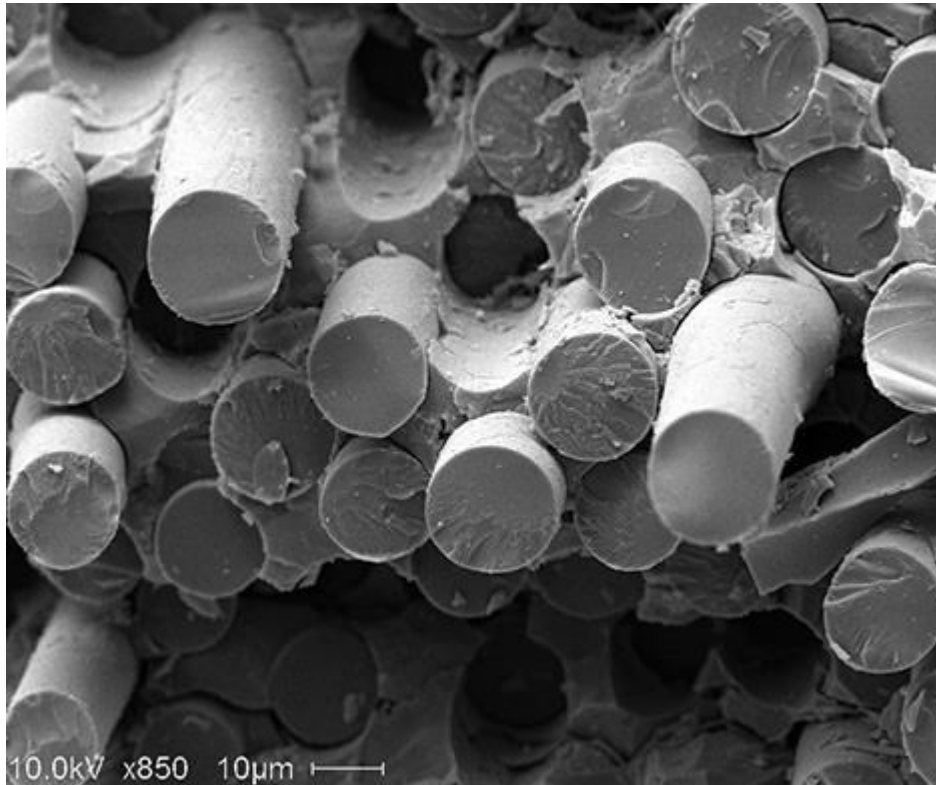


Figure Q2. Chemical vapour infiltrated (CVI) SiNC/SiC ceramic matrix composite

- (c) Spray freeze drying (SFD) has been employed successfully in producing suitable granules for dry pressing of nanocrystalline zirconia. Explain how SFD overcomes the drawbacks of spray drying and freeze drying processes in ceramic powder production. [6 marks]
- (d) Discuss the effect of reduction in grain size on the hardness of nanocrystalline materials. [4 marks]

3. (a) Identify the methods, including synthesis routes, by which silica nanofillers can be incorporated into organic coatings. In your answer identify the key processing parameters. [5 marks]
- (b) Discuss the advantages that silica nanofillers provide when included in organic coatings. In your answer provide an indication of the property improvement that the silica nanofillers might confer, if optimised. [9 marks]
- (c) Discuss two methods which might be used to determine how an organic coating comprising 3% nanosilica might be studied in order to determine the location of silica nanoparticles within the coating. [6 marks]
4. (a) Explain how gecko lizards are able to adhere to flat surfaces, such as glass. [5 marks]
- (b) What would be the key features of an adhesive which mimics the gecko lizard adhesion mechanism and detail how such an adhesive might be manufactured? [5 marks]
- (c) Give one application where an adhesive based upon gecko nanobiomimicry might be used and explain why this is the best choice of joining method for the specific application. [4 marks]
- (d) Discuss the limitations of using a gecko nano biomimicry-based adhesive in an outdoor environment for high loaded applications. [2 marks]
- (e) Give one other example of nanobiomimicry which is currently either being researched or commercially exploited. In your answer indicate:
- (i) the biological system being mimicked;
  - (ii) the application of the nanobiomimicry technology;
  - (iii) what features from nature are being utilised in the application, and;
  - (iv) the processing method used to recreate the natural structure and chemistry.

[4 marks]

END OF PAPER

**Dr S Saremi, Professor G W Critchlow**