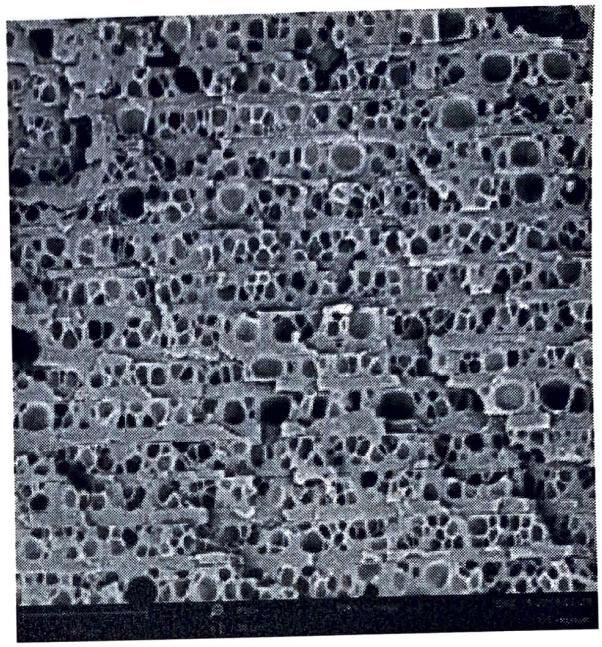
1. Biomimetic design has been utilized by researchers to create synthetic materials with unique combinations of properties previously only found in nature. Biomimetic materials often incorporate nanoscale structures in order to achieve enhanced properties that are typically not observed in the bulk material. Identify a desirable phenomenon (ie; adhesion, superhydrophobicity, self-healing behaviour, etc.) that arises in a natural material as a direct result of nanoscale features. In your own words, explain why this mechanism arises in the presence of nano-scale morphology, but not at larger size scales. What manufacturing technology would you use to try to replicate this morphology in a synthetic material? Drawings can be used to support your explanation. (30 marks)

Superhydrophobicity arises in a natural material as a direct result of nanoscale features

2. The MNL manufacturing technology can be applied to create multiphase nano-structured foams as shown in the SEM. Suppose you are using polystyrene (PS) and polycarbonate (PC) as alternating layer materials where PS will be foamed, and PC will be a film layer. (25 marks)



a. Create an MNL coextrusion setup (schematics/sketches with short descriptions) clearly showing the detailed processes used to manufacture such a structure. (10 marks)

b. Describe how the number of layers will affect the foam morphology (cell size, cell density, cell uniformity, etc.) (10 marks)

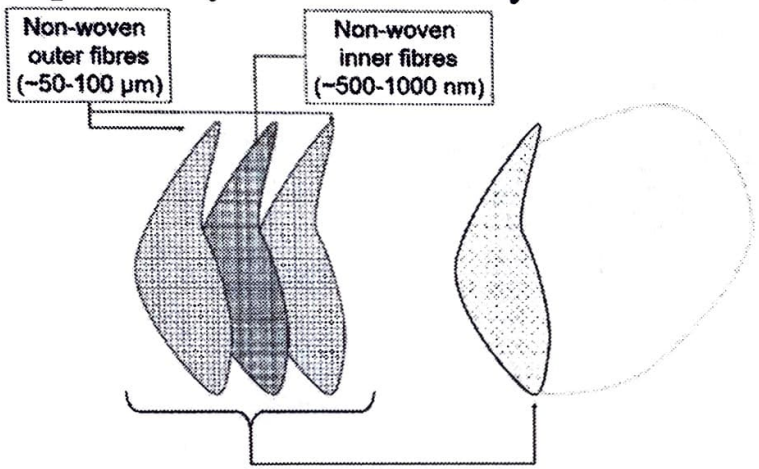
c. Describe how you would tune the foam morphology to achieve thermal insulation. Other than thermal insulation, what other benefits will your proposed foam structure offer? (5 marks)

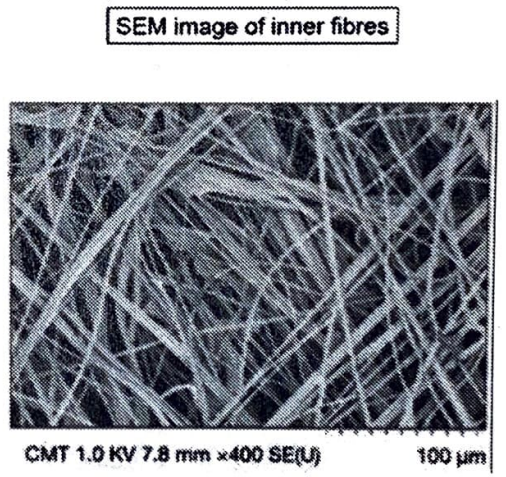
N95 respiratory masks consist of a non-woven multilayer polymer structure. The two outer layers consist of micron-size polymer fibres (provide structure and moderate filtration), which surround an inner layer of nano-scale polymer fibres (delicate fibre layer which provides a high degree of filtration). (25 marks)

a) List the names of suitable technologies that can be used to manufacture the outer (blue component in the schematic) and inner (red) layers of the mask, respectively. Describe the technologies that you think would be best to achieve a mask with the aforementioned inner and outer layer structures. (10 marks)

b) Comment on the melt viscosity of the inner and outer layer materials respectively, based on your selected technologies. (5 marks)

c) The outer layer should reject any respiratory aerosols to minimize contamination. Describe how you would use an advanced manufacturing process to enhance the hydrophobicity of the outer layers of these masks. (10 marks)





To design and produce the special micro-sized feature shown below, researchers proposed the formation of the following geometry on a silicon wafer. Please propose a detailed fabrication technique, which can be suited for this structure, with detailed description of each step. You may use Sacrificial Layers (SL), Material Layers (ML), and Photoresists (PR). SL and ML each have a different solvent for etching and PR does not get affected by these solvents. In addition, you can use CMP to make flat planar surfaces during intermediate steps if needed. (25 marks)