CLAIMS

1. A membrane comprising:

a feed flow inlet,

a retentate flow outlet,

a permeate flow outlet,

a membrane interface portion comprising a plurality of feed flow channels fluidly connected to the feed flow inlet and to the retentate flow outlet, and a plurality of permeate flow channels fluidly connected to the permeate flow outlet, wherein the membrane interface portion is operable to allow for fluid communication between the feed flow channels and the permeate flow channels through a membrane portion,

wherein the membrane interface portion comprises a reduction in a dimensional property from toward the feed flow inlet to toward the retentate flow outlet so that the membrane interface portion is operable to produce a higher cross-flow velocity at the membrane portion toward the retentate flow outlet.

2. A membrane according to claim 1, wherein the membrane is obtainable by additive manufacturing.

3. A membrane according to claim 1 or 2, wherein the membrane interface portion comprises a first unit cell layer and a second unit cell layer, wherein each unit cell layer extends substantially transversely to the direction of feed flow, and wherein each unit cell layer comprises a plurality of unit cells,

wherein the unit cells of the first and second layer each comprise a feed flow channel portion, a permeate flow channel portion and a membrane portion separating the feed flow portion and the permeate flow portion,

wherein the feed flow channel portion and the permeate flow channel portion of a unit cell is fluidly connected to the feed flow channel portion and the permeate flow channel portion of an adjacent unit cell,

and wherein the plurality of unit cells in the first unit cell layer comprise an average dimensional property that is larger than the average of the same dimensional property in the plurality of unit cells in the second unit cell layer,

and wherein the first unit cell layer is arranged closer to the feed flow inlet than the second unit cell layer.

4. A membrane according to any preceding claim, wherein the membrane interface portion comprises a plurality of unit cell layers wherein the plurality of unit cells in each subsequent unit cell layer extending from proximal to the feed flow inlet to distal to the feed flow inlet have a reducing average dimensional property.

5. A membrane according to any preceding claim, wherein the plurality of unit cells of the first and/or second unit cell layer are in the form of periodically repeating unit cell shapes.

6. A membrane according to any preceding claim, wherein the first unit cell layer comprises a higher average lateral aspect ratio than the second unit cell layer.

7. A membrane according to any preceding claim, wherein the first unit cell layer comprises an average lateral aspect ratio of at least 0.2, such as at least 0.5.

8. A membrane according to any preceding claim, wherein the second unit cell layer comprises an average lateral aspect ratio of at least 0.1, such as at least 0.4.

9. A membrane according to any preceding claim, wherein the first unit cell layer comprises a higher average feed flow direction aspect ratio than the second unit cell layer.

10. A membrane according to any preceding claim, wherein the first unit cell layer comprises an average feed flow direction aspect ratio of at least 0.5.

11. A membrane according to any preceding claim, wherein the second unit cell layer comprises an average feed flow direction aspect ratio of at least 0.1, such as at least 0.3.

12. A membrane according to any preceding claim, wherein the second unit cell layer comprises a smaller average wall thickness than the first unit cell layer.

13. A membrane according to any preceding claim, wherein the first unit cell layer has an average thickness ratio of at least 0.5, such as at least 0.8.

14. A membrane according to any preceding claim, wherein the second unit cell layer has an average thickness ratio of at least 0.1, such as at least 0.4, and/or up to 0.99, such as up to 0.8.

15. A membrane according to any preceding claim, wherein the shape of the unit cell is a diamond structure, a cubic structure, a fluorite structure, an octet structure, a Kelvin cell structure, an iso-truss structure, a hex prism diamond structure, a truncated tube

structure, a truncated octahedron structure, a Weaire-Phelan structure, a body centred cubic structure, and/or a face centred cubic structure.

16. A membrane according to any preceding claim, wherein the membrane is a microfiltration membrane, ultrafiltration membrane and/or nanofiltration membrane.

17. A membrane according to any preceding claim, wherein the membrane comprises an open porosity of at least 10%, such as at least 20%, such as at least 30%, such as at least 40%, such as at least 50%.

18. A membrane according to any preceding claim, wherein the membrane is a ceramic membrane.

19. A process for the production of a membrane according to any of claims 1 to 18, the process comprising;

    a. providing a layer of ceramic powder on a powder bed;

    b. selectively bonding a portion of the ceramic powder; and

    c. repeating steps (a)-(b) to from a 3D printed green body.

    d. optionally, post-processing the 3D printed green body to form the membrane.

20. Apparatus for reducing the ratio of divalent ions to a monovalent ion in an aqueous solution from a source aqueous solution that contains a higher ratio of divalent ions to the monovalent ion, wherein the apparatus comprises;

    optionally, a prefiltration portion operable to receive the source aqueous solution and produce a prefiltered aqueous solution;

    a first separation portion operable to receive the optionally prefiltered aqueous solution and form an intermediate aqueous solution having a lower ratio of divalent ions to the monovalent ion than the optionally prefiltered aqueous solution; and/or

    a second separation portion operable to receive the intermediate aqueous solution and form a product aqueous solution having a lower ratio of the divalent ions to the monovalent ion than the intermediate solution,

    wherein the prefiltration portion, the first and/or the second separation portion comprises a separation portion comprising a membrane according to any of claims 1 to 18.