polystyrene substrates with lotus leaf surface structures by electroforming nickel onto a natural lotus leaf to form a mold, followed by hot embossing with polystyrene.

[0010] U.S. Patent Publication No. 2011/0177288 discloses methods of making superhydrophobic structures comprising depositing a polymer mold onto a silicon surface comprising a plurality of microasperities, removing the polymer mold after the polymer mold has hardened, depositing a liquid epoxy resin into the polymer mold, forming a microstructure with a plurality of microasperities by separating the epoxy resin from the mold after the epoxy resin has solidified, and forming a superhydrophobic structure by depositing a plurality of alkane nanoasperities on the microstructure in the presence of solvent vapor.

[0011] It would be desirable to provide a simpler method for formation of hierarchical, biomimetic structures.

SUMMARY

[0012] The present disclosure relates to a method of making a synthetic polymer substrate comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, comprising forming an array of dome-shaped depressions, each having a diameter and a depth, in a solid template substrate; forming a porous surface on said dome-shaped depressions, wherein said porous surface is formed of a material different from that of said solid template substrate; and contacting said porous surface with a synthetic polymer thermoplastic film under temperature and pressure conditions sufficient to cause said thermoplastic to flow into pores of said porous surface and said

dome-shaped depressions to form an imprinted film having said hierarchical surface structure.

[0012a] In one aspect, there is provided a method of making a synthetic polymer substrate comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, comprising: forming an array of dome-shaped depressions, each having a diameter and a depth, in a solid template substrate selected from a silicon wafer or a metal substrate; forming a porous surface on said dome-shaped depressions, wherein said porous surface is formed of a material different from that of said solid template substrate; and contacting said porous surface with a synthetic polymer thermoplastic film under temperature and pressure conditions sufficient to cause said thermoplastic to flow into pores of said porous surface and said dome-shaped depressions to form an imprinted film having said hierarchical surface structure.

[0012b] In another aspect, there is provided a method of making a synthetic polymer substrate comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, comprising: forming an array of dome-shaped depressions by micromachining, each having a diameter and a depth, in a metal substrate; forming a porous surface on said dome-shaped depressions, wherein said porous surface is a free standing polycarbonate filter membrane having pores therein, which is placed on the surface of said solid template substrate and forced into said dome-shaped depressions under said temperature and pressure conditions; contacting said porous surface with a synthetic polymer thermoplastic film under temperature and pressure conditions sufficient to cause said thermoplastic to flow into pores of said porous surface and said dome-shaped depressions to form an imprinted film having said hierarchical surface structure; and removing a combined polycarbonate filter

membrane and polymer film from said mold and dissolving said polycarbonate filter membrane with a solvent, leaving said polymer substrate comprising a hierarchical surface structure.

[0013] In another example, the present example is directed to a synthetic polymer substrate comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, wherein said substrate is a synthetic polymer film, said domes have diameters in the range from about 5 μm to about 400 μm, heights in the range from about 2.5 μm to about 500 μm, and said pillars have diameters in the range from about 20 nm to about 5 μm and aspect ratios of from about 2 to about 50.

[0014] In a further example, the present example is directed to a medical device, comprising a substrate having a synthetic polymer film comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, wherein said synthetic polymer film is a thermoplastic polymer film, said domes have diameters in the range from about 5 μm to about 400 μm, heights in the range from about 2.5 μm to about 500 μm, and said pillars have diameters in the range from about 20 nm to about 5 μm and aspect ratios of from about 2 to about 50.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figures 1A and 1B show FE-SEM images of top and cross-sectional views, respectively, of a porous anodic alumina (PAA) template prepared by the inventive process.

What is Claimed:

1. A method of making a synthetic polymer substrate comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, comprising:

forming an array of dome-shaped depressions, each having a diameter and a depth, in a solid template substrate selected from a silicon wafer or a metal substrate;

forming a porous surface on said dome-shaped depressions, wherein said porous surface is formed of a material different from that of said solid template substrate; and

contacting said porous surface with a synthetic polymer thermoplastic film under temperature and pressure conditions sufficient to cause said thermoplastic to flow into pores of said porous surface and said dome-shaped depressions to form an imprinted film having said hierarchical surface structure.

2. The method of claim 1, wherein when said solid template substrate is the silicon wafer, said dome-shaped depressions are formed by lithography and dry etching.

3. The method of claim 2, wherein said porous surface is porous anodic alumina, formed by depositing an aluminum film on said dome-shaped depressions and anodizing the aluminum film.

4. The method of claim 1, wherein said dome-shaped depressions have diameters in the range from 5 μm to 400 μm, depths in the range from 2.5 μm and 500 μm, and pores created in said porous surface have diameters in the range from 20 nm to 5 μm and aspect ratios of from 2 to 50.

5. The method of claim 2, wherein said dome-shaped depressions have diameters in the range from 10 μm to 40 μm, depths in the range from 5 μm to 20 μm, and the pores have diameters in the range from 20 nm to 500 nm and aspect ratios of from 2 to 50.

6. The method of claim 5, wherein said pores have an average pore diameter of about 200 nm and an average depth of about 500 nm.

7. The method of claim 1, wherein said synthetic polymer of said thermoplastic film is selected from the group consisting of polypropylene, polycarbonate and polydioxanone, and the thickness of said film exceeds the depth of said dome-shaped depressions.

8. The method of claim 1, further comprising de-molding said imprinted film from said solid template substrate.

9. The method of claim 1, wherein when said solid template substrate is the metal substrate, said dome-shaped depressions are formed by micromachining.

10. The method of claim 9, wherein said porous surface is a free standing track etched membrane having pores therein, which is placed on the surface of said solid template substrate and forced into said dome-shaped depressions under said temperature and pressure conditions.

11. The method of claim 10, wherein said dome-shaped depressions have diameters in the range from 50 μm to 400 μm, depths in the range from 50 μm and 100 μm, and said pores have diameters in the range from 200 nm to 3 μm and aspect ratios of from 2 to 50.

12. The method of claim 11, wherein said pores have diameters in the range from 0.4 μm to 3 μm.

13. The method of claim 10, further comprising placing said synthetic polymer thermoplastic film onto said track etched membrane, and applying said temperature and pressure conditions to said synthetic polymer thermoplastic film so as to force thermoplastic polymer from a surface of said film into the pores of said free standing track etched membrane and into the dome shaped depressions in said metal substrate.

14. The method of claim 10, wherein said free standing track etched membrane is a polycarbonate filter membrane.

15. The method of claim 10, wherein said free standing track etched membrane is a polycarbonate filter membrane, further comprising removing a combined polycarbonate filter membrane and polymer film from said mold and dissolving said polycarbonate filter membrane with a solvent, leaving said polymer substrate comprising a hierarchical surface structure.

16. A method of making a synthetic polymer substrate comprising a hierarchical surface structure of multiple domes and multiple pillars on said domes, comprising:

forming an array of dome-shaped depressions by micromachining, each having a diameter and a depth, in a metal substrate;

forming a porous surface on said dome-shaped depressions, wherein said porous surface is a free standing polycarbonate filter membrane having pores therein, which is placed on the surface of said solid template substrate

and forced into said dome-shaped depressions under said temperature and pressure conditions;

contacting said porous surface with a synthetic polymer thermoplastic film under temperature and pressure conditions sufficient to cause said thermoplastic to flow into pores of said porous surface and said dome-shaped depressions to form an imprinted film having said hierarchical surface structure; and

removing a combined polycarbonate filter membrane and polymer film from said mold and dissolving said polycarbonate filter membrane with a solvent, leaving said polymer substrate comprising a hierarchical surface structure.