WHAT IS CLAIMED IS:

1. An anti-fouling implantable material, comprising:

a reinforcement layer comprising a plurality of polymeric filaments comprising a filament polymer, the reinforcement layer having a first surface and an opposing surface;

an intermediate layer comprising a protection membrane attached to at least a portion of the first surface, the protection membrane comprising a protective polymer, optionally wherein the intermediate layer further comprises a second protection membrane attached to at least a portion of the opposing surface of the reinforcement layer, the second protection membrane comprising a second protective polymer, wherein the second protective polymer of the second protection membrane may have the same or a different chemical composition than the protective polymer; and

an outer layer comprising an ionic polymer grafted onto an exposed surface of the intermediate layer,

wherein the polymeric filaments comprise a core and a shell surrounding the core, wherein the core comprises the filament polymer and the shell comprises a shell polymer, wherein the shell polymer is a biostable polymer comprising hydrolyzed poly(ethylene terephthalate).

2. The anti-fouling implantable material of claim 1, wherein the polymeric filaments of the reinforcement layer:

are randomly oriented to form a material comprising entangled polymer filaments; or

are aligned unidirectionally; or

form an interwoven mesh comprising a first plurality of polymeric filaments having a first common extending direction interwoven with a second plurality of polymeric filaments having a second common extending direction, the second common extending direction orthogonal to the first common extending direction; or

form an intra-lamellar mesh comprising a plurality of lamellae, wherein polymeric filaments in each lamella have a common extending direction, and polymeric filaments in adjacent lamellae are oriented in different extending directions; or

are knitted to form a knitted material; or

are twisted into yarn fibers comprising a plurality of polymeric filaments,

wherein the yarn fibers subsequently are (i) randomly oriented to form a material comprising randomly oriented, entangled yarn fibers, (ii) aligned unidirectionally, (iii) woven to form an interwoven mesh, (iv) aligned to form an intra-lamellar mesh comprising a plurality of lamellae, or (v) knitted to form a knitted material.

3. The anti-fouling implantable material of claim 1 or claim 2, wherein:

a) the filament polymer comprises a polyurethane, a polyether ketone, a poly(ethylene terephthalate), a polycarbonate, a polyester, a polyacrylate, a polysiloxane, an aromatic polyolefin, an aliphatic polyolefin, a polyamide, a glycerol-ester polymer, a polycarboxylic acid, a polysulfone, a polysaccharide, a polyamine, a polyamino acid, a polypeptide, or any combination thereof; and/or

b) the filament polymer is a biostable polymer comprising a polyurethane, a polyester, poly(ethylene terephthalate), a polycarbonate, a polysiloxane, an aromatic polyolefin, or an aliphatic polyolefin; or

the filament polymer is a biodegradable polymer comprising poly(lactic acid), poly(lactic-co-glycolic acid), a polysaccharide, a polyamino acid, a polypeptide, or poly(glycerol sebacate); and/or

c) the polymeric filaments have an average diameter within a range of from 0.001 μm to 2000 μm.

4. The anti-fouling implantable material of any one of claims 1–3, wherein the reinforcement layer has:

(i) a thickness within a range of from 25 μm to 500 μm; or

(ii) a burst strength within a range of from 50–800 N (ASTM D3787-01); or

(iii) a tensile strength within a range of from 50–800 N (ASTM D412); or

(iv) any combination of (i), (ii), and (iii).

5. The anti-fouling implantable material of any one of claims 1–4, wherein the protective polymer comprises:

a biostable synthetic polymer selected from polyethylene, polypropylene, polytetrafluoroethylene, a polyether, polycarbonate polyurethane, polysiloxane polyurethane, a polyether polyurethane elastomer, a polyester polyurethane elastomer, a silicone, a polycarbonate, a polysulfone, polyether ether ketone, poly(ethylene terephthalate), a polyester, or any combination thereof; or

a biodegradable synthetic polymer selected from a polyester, a polyacrylate, a polyamide, a hydrophilic polyester polyurethane, a hydrophilic polyurea, poly(amide-enamine), a polyanhydride, a poly(ester amide), poly(glycolide), polylactic acid, polyglycolic acid, polycaprolactone, poly(hydroxy butyrate), poly(ε-caprolactone), poly(vinyl alcohol)-hyaluronic acid, a hyaluronate amine, a ureidopyrimidinone-based polymer, or any combination thereof; or

a hydrogel-forming polymer selected from a protein, a polysaccharide, a hydrophilic polyurethane, poly(ethylene oxide), polyacrylamide, a polyethylene glycol, a polyacrylate, a polypeptide, poly(glycerol sebacate), poly(xylitol sebacate), or any combination thereof.

6. The anti-fouling implantable material of any one of claims 1–5, wherein the intermediate layer has:

(i) an average thickness within a range of from 0.1 μm to 100 μm; or

(ii) a durometer Shore hardness within a range of from 10A to 80A (ASTM D785); or

(iii) a flexural modulus within a range of from 1 N/mm^2 to 50 N/mm^2 (ASTM D790); or

(iv) a dry ultimate tensile strength within a range of from 10 N/mm^2 to 60 N/mm^2 (ASTM D412); or

(v) a wet ultimate tensile strength within a range of from 5 N/mm^2 to 40 N/mm^2 (ASTM D412); or

(vi) any combination of (i), (ii), (iii), (iv), and (v).

7. The anti-fouling implantable material of any one of claims 1–6, wherein the ionic polymer is an anionic polymer, a cationic polymer, or a zwitterionic polymer, optionally wherein the ionic polymer comprises:

a) a poly(phosphocholine), a poly(sulfobetaine), a poly(carboxybetaine), a zwitterionic polysaccharide, diethyl ethanolamine quaternized with 2-acrylamide-2-methylpropane sulfonic acid and acrylic acid, or any combination thereof; and/or

b) poly(2-methacryloyloxyethyl phosphorylcholine) (MPC); or poly(MPC-co-2-ethylhexyl methacrylate-co-*N,N*-diethylaminoethyl methacrylate); or

poly(MPC-co-*p*-nitrophenyloxycarbonyl poly(ethylene glycol) methacrylate); or

a poly(2-hydroxyethyl methacrylate)-MPC copolymer; or

a polyvinylpyrrolidone-MPC copolymer; or

any combination thereof.

8. The anti-fouling implantable material of any one of claims 1–7, wherein the outer layer has an average thickness within a range of from 0.001 μm to 25 μm.

9. An implantable medical device comprising an anti-fouling implantable material according to any one of claims 1–8 wherein the implantable medical device comprises:

a) a prosthetic heart valve, a vascular graft, an annuloplasty ring, a cardiovascular patch, or a coaptation clip; or b) a prosthetic heart valve comprising a plurality of leaflets, a sealing skirt, a covering for a metal component, or any combination thereof, formed from the anti-fouling implantable material.

10. A method for making an anti-fouling implantable material, comprising:

forming an intermediate layer comprising a protection membrane on at least a portion of a first surface of a reinforcement layer, the reinforcement layer comprising a plurality of polymeric filaments comprising a filament polymer, and the protection membrane comprising a protective polymer; and

forming an outer layer by grafting an ionic polymer onto an exposed surface of the intermediate layer,

wherein the polymeric filaments comprise a core comprising the filament polymer and a shell surrounding the core, the shell comprising a shell polymer, wherein the method further comprising forming the core and hydrolyzing a surface of the core to form the shell.

11. The method of claim 10, further comprising:

a) forming the plurality of polymeric filaments comprising the filament polymer by jet spinning, electro-spinning, melt spinning, three-dimensional printing, extrusion, or a melt-blown process; and/or

b) forming a plurality of leaflets from the anti-fouling implantable material and coupling the leaflets to a frame of a prosthetic heart valve.

12. The method of claim 10 or claim 11, further comprising forming the reinforcement layer by:

jet spinning, electro-spinning, or melt spinning the plurality of polymeric filaments to form a material comprising randomly oriented, entangled filaments; or

aligning the plurality of polymeric filaments unidirectionally; or

weaving the plurality of polymeric filaments to form an interwoven mesh comprising a first plurality of filaments having a first common extending direction interwoven with a second plurality of filaments having a second common extending direction, the second common extending direction orthogonal to the first common extending direction; or

aligning the plurality of polymeric filaments to form an intra-lamellar mesh comprising a plurality of lamellae, wherein filaments in each lamella have a common extending direction, and filaments in adjacent lamellae are oriented in different extending directions; or

knitting the plurality of polymeric filaments to form a knitted material; or

twisting the plurality of polymeric filaments to form yarn fibers, and subsequently (i) randomly orienting the yarn fibers for form a material comprising randomly oriented, entangled yarn fibers, (ii) aligning the yarn fibers unidirectionally, (iii) weaving the yarn fibers to form an interwoven mesh, (iv) aligning the yarn fibers to form an intra-lamellar mesh comprising a plurality of lamellae, or (v) knitting the yarn fibers to form a knitted material; or

printing the plurality of polymeric filaments in a pattern by three-dimensional printing.

13. The method of any one of claims 10–12, wherein forming the intermediate layer comprising the protection membrane on at least a portion of the first surface of the reinforcement layer further comprises:

thermally attaching the protection membrane to at least a portion of the first surface; or

mechanically attaching the protection membrane to at least a portion of the first surface; or

ultrasonically attaching the protection membrane to at least a portion of the first surface; or

attaching the protection membrane to at least a portion of the first surface using a laser; or

chemically attaching the protection membrane to at least a portion of the first surface by hydrolysis or oxidation of the reinforcement layer and protective polymer, whereby chemical functional groups of the filament polymer or shell polymer react with functional groups of the protective polymer; or

coating the reinforcement layer with a solution comprising the protective polymer and a solvent, and removing the solvent to form the protection membrane; or

forming the protection membrane from a solution comprising the protective polymer by a reactive dip-coating process; or

coating the reinforcement layer with a solution comprising the protective polymer and curing the protective polymer by ultraviolet irradiation; or

printing the protection membrane onto at least a portion of the first surface by a three-dimensional printing process.

14. The method of any one of claims 10–13, wherein grafting the ionic polymer onto the exposed surface of the intermediate layer comprises:

coating the exposed surface with a solution comprising the ionic polymer to form an ionic polymer-coated material; and

drying the ionic polymer-coated material.