WHAT IS CLAIMED IS:

1. A method of fabricating a microchannel vascular network device, the method comprising:

(A) determining, based on a plurality of design criteria, a microchannel vascular network design, wherein the microchannel vascular network design comprises:

a first channel network,

a second microchannel network based on the first channel network, and

a structure for providing fluidic communication through between the first channel network and the second channel network;

(B) receiving, in electronic form, the microchannel vascular network design at a fabrication system, wherein the fabrication system comprises a pre-polymer solution; and

(C) forming, based on the microchannel vascular network design, a microchannel vascular network device of a polymer material at the fabrication system using the pre-polymer solution, thereby fabricating the microchannel vascular network device.

2. The method of claim 1, wherein the determining (A) further comprises determining one or more design criteria in the plurality of the design criteria that is associated with the forming (C) of the polymer material from the pre-polymer solution.

3. The method according to either of claim 1 or 2, wherein the polymer material comprises poly-dimethyl-siloxane (PDMS), poly-glycerol-sebacate (PGS), polylactic acid (PLA), poly-L-lactic acid (PLLA), poly-D-lactic acid (PDLA), polyglycolide, polyglycolic acid (PGA), polylactide-co-glycolide (PLGA), polydioxanone, polygluconate, polylactic acid-polyethylene oxide copolymers, modified cellulose, collagen, polyhydroxybutyrate, polyhydroxpriopionic acid, polyphosphoester, poly(alpha-hydroxy acid), polycaprolactone, polycarbonates, polyamides, polyanhydrides, polyamino acids, polyorthoesters, polyacetals, polycyanoacrylates, degradable urethanes, aliphatic polyesterspolyacrylates, polymethacrylate, acyl substituted cellulose acetates, non-degradable polyurethanes, polystyrenes, polyvinyl chloride, polyvinyl flouride, polyvinyl imidazole, chlorosulphonated polyolifins, polyethylene oxide, polyvinyl alcohol, Teflon©, nylon silicon, and shape memory materials, such as poly(styrene-block-butadiene), polynorbornene, hydrogels, metallic alloys, and oligo(ε-caprolactone)diol as switching segment/oligo(p-dioxyanone)diol as physical crosslink.

4. The method according to any one of claims 1-3, wherein the polymer is a biodegradable material.

5. The method according to any one of claims 1-4, wherein:

the pre-polymer solution comprises a photoinitiator, and

wherein the forming (C) comprises exposing the pre-polymer solution to ultraviolet light for a predetermined period of time.

6. The method according to any one of claims 1-5, wherein the polymer material of the microchannel vascular network device is transparent.

7. The according to any one of claims 1-6, wherein the structure comprises:

a first end portion in communication with the first channel network, wherein the first end portion comprising a first diameter,

a second end portion in communication with the second channel network, the second end portion comprising a second diameter, and

wherein the first diameter and the second diameter of the structure define an interior transition region of the structure.

8. The method of claim 7, wherein the first diameter is different from the second diameter.

9. The method according to either of claim 7 or 8, wherein:

the first diameter is from about 992 microns (μm) to about 623 μm, and

the second diameter is from about 832 μm to about 553 μm.

10. The method according to any one of claims 7-9, wherein the interior transition region of the structure comprises an interior surface define by revolving a continuous, smooth curve about an axis of the structure.

11. The method of claim 10, wherein the continuous, smooth curve comprises a conical shape, an ellipsoidal shape, or a cylindrical shape.

12. The method according to any one of claims 7-9, wherein the interior transition region of the structure comprises an interior surface define by a monotonic function.

13. The method according to any one of claims 7-12, wherein the interior transition region of the structure comprises a corresponding length from about 399 μm to about 701 μm.

14. The method according to any one of claims 1-13, wherein a length defined from a first end portion to a second end portion of the microchannel vascular network device is from about 15 centimeters (centimeters) to about 7.5 cm.

15. The method according to any one of claims 1-14, wherein the plurality of design criteria comprise one or more length design criteria, one or more mass design criteria, one or more temporal design criteria, one or more polymer design criteria, one or more temporal design criteria, one or more illuminance design criteria, or a combination thereof.

16. The method of claim 15, wherein the one or more length design criteria in the plurality of design criteria of the determining (A) comprises:

a first length associated with the microchannel vascular network design,

a second length associated with the microchannel vascular network device, and

wherein the second size is less than the first size.

17. The method of claim 16, wherein the second length is based on the first length, the polymer, the fabrication system, or a combination thereof.

18. The method according to any one of claims 15-17, wherein the one or more polymer design criteria in the plurality of design criteria comprises selecting the polymer of the forming (C) based on a degree of swelling of the polymer.

19. The method according to any one of claims 15-18, wherein the one or more length design criteria in the plurality of design criteria comprises a resolution of a length of the microchannel vascular network device.

20. The according to any one of claims 15-19, wherein the one or more polymer design criteria in the plurality of design criteria comprises a porosity of the microchannel vascular network device.

21. The method of claim 20, wherein a median size of a pore of the microchannel vascular network device is from about 19 μm to about 231 μm.

22. The method according to any one of claims 1-21, wherein the fabrication system utilizes an additive manufacturing method for the forming (C).

23. The method according to any one of claims 1-22, wherein the forming (C) forms the microchannel vascular network device with a positive mold, thereby forming a void in between the first channel network and the second channel network.

24. The method according to any one of claims 1-22, wherein the forming (C) forms the microchannel vascular network device with a positive mold, thereby forming a void in between the first channel network and the second channel network.

25. The method according to any one of claims 22-24, wherein the additive manufacturing method is selected from the group consisting of: binder jetting, material extrusion, material jetting, polyjet, powder bed, sheet lamination, and vat photopolymerization.

26. A method of retarding or arresting flow in a microchannel device, wherein:

the microchannel device comprises a first channel and a second channel, the first channel and the second channel being interconnected by one or more structures, and wherein the method comprises:

perfusing a suspension comprising a plurality of GelMA microgels in a solution through a first channel of the device, wherein the perfusing the solution causes one or more GelMA microgels to retard or arrest flow in at least one of the one or more structures.

27. The method of claim 26, wherein the plurality of GelMA microgels is fabricated using a photomasking technique.

28. The method of claim 27, wherein the photomasking technique comprises:

disposing a pre-polymer solution comprising GelMA in a buffer solution and a photoinitiator onto a first slide whose outer edge portion is surrounded by a spacer, and wherein a second slide is disposed above the first slide upon completion of the disposing of the pre-polymer solution onto the first slide, thereby forming a contained structure;

disposing a photomask on a top surface of the second slide; and

exposing the photomask and the contained structure to ultraviolet light for a predetermined period of time, thereby generating GelMA microgels.

29. The method of claim 28, wherein the method further comprises disassembling the contained structure to retrieve the generated GelMA microgels, thereby fabricating the plurality of GelMA microgels.

30. The method according to either of claims 28 or 29, wherein the pre-polymer solution comprises:

of from about 7% to about 20% parts by weight GelMA, and

about 1% photoinitiator.

31. The method according to any one of claims 28-30, wherein pre-polymer solution is formed with a degree of methacryloyl substitution of from about 75% to about 90%.

32. The method according to any one of claims 28-31, wherein the array of transparencies is an array of circles, and wherein each circle in the array of circles has a diameter of from about 50 micrometers (μm) to about 650 μm.

33. The method according to any one of claims 28-32, wherein the spacer has a thickness of from about 50 μm to about 550 μm.

34. The according to any one of claims 28-33, wherein prior to the disposing the pre-polymer solution, for at least one slide and/or spacer the method further comprises:

disposing a sample of a stock solution of about 0.5 wt% of methoxy polyethylene glycol 5000 Si (mPEG5000-Si), about 1 wt% acetic acid, and ethyl alcohol onto the at least one slide and/or spacer;

subjecting the at least one slide and/or spacer to an incubation at about 70 °C for about 30 minutes, thereby forming an incubated slide and/or spacer;

immersing the incubated slide and/or spacer in deionized water, thereby forming an immersed slide and/or spacer;

sonicating the immersed slide and/or spacer for a predetermined period of time, thereby forming a sonicated slide and/or spacer; and

drying the sonicated slide and/or spacer, thereby forming a prepared slide and/or spacer.

35. The method according to any one of claims 28-34, wherein the predetermined period of time is less than or equal to about 30 seconds.

36. The method according to any one of claims 28-35, wherein the ultraviolet light has:
a wavelength of from about 360 nanometers (nm) to about 480 nm, and
an intensity of about 12.4 milliwatts per cubic centimeter.

37. The method according to any one of claims 28-36, wherein the retrieving the GelMA microgels comprises:
transferring the generated GelMA microgels into a mineral oil bath, and
agitating the mineral oil bath.

38. The method according to any one of claims 28-36, wherein the retrieving the GelMA microgels comprises:
(a) immersing the generated GelMA microgels in a sodium hydroxide solution;
(b) immersing the GelMA microgels of (a) in an ethyl alcohol solution; and
(c) sonicating the GelMA microgels of (b) for a third predetermined period of time.

39. The method according to any one of claims 26-38, wherein the plurality of GelMA microgels is fabricated using a microfluidic process.

40. The method according to any one of claims 26-39, wherein one or more GelMA microgel in the plurality of GelMA microgels is formed as a sphere.

41. The method according to any one of claims 26-40, wherein the one or more structures is in a shape of a truncated cone.

42. The method according to any one of claims 26-41, wherein the method further comprises:
subsequent to the perfusing the suspension of the plurality of GelMA microgels and the first solution through the first channel of the device, applying a flow of fluid in the second channel of the device, thereby creating a pressure differential between the first channel and the second channel of the device.

43. A bioreactor system for controlling a flow through a microchannel vascular network device, the bioreactor system comprising:
one or more processors;
memory coupled to the one or more processors,
a controller coupled to the memory and the one or more processors

the microchannel vascular network device comprising:

an inlet channel comprising a first inflow opening and a first outflow opening,

a well that is configured to hold a cell culture insert, the well comprising:

an inlet in communication with the first outflow opening,

an outlet that is disposed below the cell culture insert and in communication with a second inflow opening of an outlet channel, and

the outlet channel comprising the second inflow opening an a second outflow opening; and

a pump coupled to the microchannel vascular network device and configured to promote a flow of a fluid through the microchannel vascular network device from the inlet channel through the outlet channel based on one or more instructions provided by the controller.

44. The bioreactor system of claim 43, wherein the bioreactor system further comprises a caplet disposed above the cell culture insert and removably coupled to the microchannel vascular network device.

45. The bioreactor system of claim 44, wherein the caplet of the device comprises a second outlet.

46. The bioreactor system according to either of claim 44 or 45, wherein the caplet is shaped as an inverted funnel.

47. The bioreactor system according to any one of claims 44-46, wherein the caplet is coupled to the well via an O-ring.

48. The bioreactor system according to any one of claims 44-47, wherein each surface of the caplet that is in contact with at least a wall of the well includes a hydrophobic material.

49. The bioreactor system of claim 47, wherein the O-ring includes a hydrophobic material.

50. The bioreactor system according to any one of claims 43-49, wherein the cell culture insert is a sponge or a mesh.

51. The bioreactor system according to any one of claims 43-50, wherein the cell culture insert is coated in gelatin.

52. The bioreactor system according to any one of claims 43-51, wherein the bioreactor system comprises:

a plurality of microchannel vascular network devices connected in series and in fluidic communication with each other such that a respective inlet channel of a second microchannel vascular network device in the plurality microchannel vascular network devices is coupled to a respective outlet channel of a first microchannel vascular network device.

53. The bioreactor system according to any one of claims 43-52, wherein the bioreactor system comprises:

a plurality of microchannel vascular network devices, wherein the plurality of microchannel vascular network devices is connected in parallel, such that each microchannel vascular network device the plurality of microchannel vascular network devices is coupled to the pump.

54. A method of culturing a plurality of cells in a microchannel vascular network device, the method comprising:

(A) preparing, based on a candidate subject, a microchannel vascular network device, thereby forming a prepared microchannel vascular network device, wherein the prepared microchannel vascular channel device comprises:

a first channel network, and

a second channel network;

(B) seeding, based on the candidate subject, the plurality of cells for culturing in the prepared microchannel vascular device, thereby forming a plurality of seed cells; and

(C) flowing, using a bioreactor system coupled to the prepared microchannel vascular network device, a culture medium comprising the plurality of seed cells through the prepared microchannel vascular network device, thereby culturing the plurality of cells in the microchannel vascular network device.

55. The method of claim 54, the preparing (A) further comprises, preparing the plurality of cells for the seeding (B).

56. The method aof claim 55, wherein the preparing (A) the plurality of cells comprises exposing the plurality of cells to a solution comprising calcium and magnesium.

57. The method of claim 56, wherein an exposure time of the plurality of cells to the solution is from about 15 minutes to about 25 minutes.

58. The method according to any one of claims 54-57, wherein the preparing (A) the microchannel vascular network device comprises modifying a surface of the microchannel vascular network device.

59. The method of claim 58, wherein the surface modification of the microchannel vascular network device is a chemical surface modification.

60. The method of claim 59, wherein the chemical surface modification comprises forming a peptide conjugation on the surface of the microchannel vascular network device.

61. The method of claim 60, wherein the peptide conjugation is an arginylglycylaspartic acid peptide.

62. The method according to any one of claims 58-61, wherein the surface modification of the microchannel vascular network device is a mechanical surface modification.

63. The method of claim 62, wherein the mechanical surface modification comprises applying a coating to the surface of the microchannel vascular network device.

64. The method of claim 63, wherein the coating comprises collagen, fibronectin, gelatin, GelMA, PEGdA, PLL, or a combination thereof.

65. The method of either of claim 63 or 64, wherein the coating comprises:

a first percentage by weight (wt%) of PEGdA from about 8% to about 12%, and

a second wt% of GelMa from about 0.5% to about 7%.

66. The method of claim 65, wherein:

the first wt% of PEGdA is 10%, and

the second wt% of GelMA from about 1% to about 5%.

67. The method according to any one of claims 63-57, wherein the coating comprises:

a first coating comprising PEGdA, PPL, GelMA, or a combination thereof, the first coating having an first upper surface and a first lower surface;

a second coating comprising either collagen or gelatin, the second coating having second upper surface and a second lower surface; and

wherein:

the first lower surface is adjacent to the surface of the microchannel vascular network device, and

the second lower surface is adjacent to the first upper surface.

68. The method according to any one of claims 54-67, wherein the seeding (B) comprises encapsulating the plurality of cells in the culture medium.

69. The method of claim 68, wherein:

the culture medium comprises a photoinitiator, and

preceding the encapsulating the plurality of cells, the seeding (B) further comprises exposing the culture medium and the plurality of cells to ultraviolet light for a predetermined period of time.

70. The method according to either of claim 68 or 69, wherein the culture medium comprises a thickness from about 5 μm to about 15 μm.

71. The method according to any one of claims 54-70, wherein a density of the plurality of seed cells of the seeding (B) is between $1*10^4$ cells per square cm to $1*10^5$ cells per square cm.

72. The method according to any one of claims 54-71, wherein a flow rate of the flowing (C) is from about 375 microliters (μL) per minute to about 425 μL per minute.

73. The method according to any one of claims 54-72, wherein prior to the flowing (C), a portion of the prepared microchannel vascular network device is in either a dry condition or a hydrated condition.

74. The method according to any one of claims 54-73, wherein prior to the flowing (C), the portion of the prepared microchannel vascular network device is a lower end portion of the microchannel vascular network device.

WHAT IS CLAIMED IS:

1. A method of retarding or arresting flow in a microchannel device, wherein:

the microchannel device comprises a first channel and a second channel, the first channel and the second channel being interconnected by one or more structures, and wherein the method comprises:

perfusing a suspension comprising a plurality of GelMA microgels in a solution through a first channel of the device, wherein the perfusing the solution causes one or more GelMA microgels to retard or arrest flow in at least one of the one or more structures.

2. The method of claim 1, wherein the plurality of GelMA microgels is fabricated using a photomasking technique.

3. The method of claim 2, wherein the photomasking technique comprises:

disposing a pre-polymer solution comprising GelMA in a buffer solution and a photoinitiator onto a first slide whose outer edge portion is surrounded by a spacer, and wherein a second slide is disposed above the first slide upon completion of the disposing of the pre-polymer solution onto the first slide, thereby forming a contained structure;

disposing a photomask on a top surface of the second slide; and

exposing the photomask and the contained structure to ultraviolet light for a predetermined period of time, thereby generating GelMA microgels.

4. The method of claim 3, wherein the method further comprises disassembling the contained structure to retrieve the generated GelMA microgels, thereby fabricating the plurality of GelMA microgels.

5. The method according to either of claims 3 or 4, wherein the pre-polymer solution comprises:

of from about 7% to about 20% parts by weight GelMA, and

about 1% photoinitiator.

6. The method according to any one of claims 3-5, wherein pre-polymer solution is formed with a degree of methacryloyl substitution of from about 75% to about 90%.

7. The method according to any one of claims 3-6, wherein the photomask comprises an array of transparencies comprising an array of circles, and wherein each circle in the array of circles has a diameter of from about 50 micrometers (μm) to about 650 μm.

8. The method according to any one of claims 3-7, wherein the spacer has a thickness of from about 50 μm to about 550 μm.

9. The method according to any one of claims 3-8, wherein prior to the disposing the pre-polymer solution, for at least one slide and/or spacer the method further comprises:

disposing a sample of a stock solution of about 0.5 wt% of methoxy polyethylene glycol 5000 Si (mPEG5000-Si), about 1 wt% acetic acid, and ethyl alcohol onto the at least one slide and/or spacer;

subjecting the at least one slide and/or spacer to an incubation at about 70 °C for about 30 minutes, thereby forming an incubated slide and/or spacer;

immersing the incubated slide and/or spacer in deionized water, thereby forming an immersed slide and/or spacer;

sonicating the immersed slide and/or spacer for a predetermined period of time, thereby forming a sonicated slide and/or spacer; and

drying the sonicated slide and/or spacer, thereby forming a prepared slide and/or spacer.

10. The method according to any one of claims 3-9, wherein the predetermined period of time is less than or equal to about 30 seconds.

11. The method according to any one of claims 3-10, wherein the ultraviolet light has:

a wavelength of from about 360 nanometers (nm) to about 480 nm, and

an intensity of about 12.4 milliwatts per cubic centimeter.

12. The method according to any one of claims 4-11, wherein the retrieving the GelMA microgels comprises:

transferring the generated GelMA microgels into a mineral oil bath, and

agitating the mineral oil bath.

13. The method according to any one of claims 4-11, wherein the retrieving the GelMA microgels comprises:

(a) immersing the generated GelMA microgels in a sodium hydroxide solution;

(b) immersing the GelMA microgels of (a) in an ethyl alcohol solution; and

(c) sonicating the GelMA microgels of (b) for a third predetermined period of time.

14. The method according to any one of claims 1-13, wherein the plurality of GelMA microgels is fabricated using a microfluidic process.

15. The method according to any one of claims 1-14, wherein one or more GelMA microgel in the plurality of GelMA microgels is formed as a sphere.

16. The method according to any one of claims 1-15, wherein the one or more structures is in a shape of a truncated cone.

17. The method according to any one of claims 1-16, wherein the method further comprises:

subsequent to the perfusing the suspension of the plurality of GelMA microgels and the first solution through the first channel of the device, applying a flow of fluid in the second channel of the device, thereby creating a pressure differential between the first channel and the second channel of the device.