WHAT IS CLAIMED IS:

1. A preceramic resin for forming a porous polymer-derived ceramic material, the resin comprising:

a) a first functionalised organosilicon monomer having a first ceramic yield; and

b) one or more of:

i. a second functionalised organosilicon monomer having a second ceramic yield;

ii. a functionalised organic monomer;

iii. porous ceramic particles; and

iv. a porogen

2. The preceramic resin according to claim 1, comprising one of the following combinations:

a) a first functionalised organosilicon monomer having a first ceramic yield and one or both of a second functionalised organosilicon monomer having a second ceramic yield and a functionalised organic monomer;

b) a first functionalised organosilicon monomer having a first ceramic yield and porous ceramic particles;

c) a first functionalised organosilicon monomer having a first ceramic yield and a porogen;

d) a first functionalised organosilicon monomer having a first ceramic yield, porous ceramic particles and a porogen;

e) a first functionalised organosilicon monomer having a first ceramic yield, one or both of a second functionalised organosilicon monomer having a second ceramic yield and a functionalised organic monomer, and porous ceramic particles;

f) a first functionalised organosilicon monomer having a first ceramic yield, one or both of a second functionalised organosilicon monomer having a second ceramic yield and a functionalised organic monomer, and a porogen; and

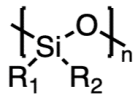
g) a first functionalised organosilicon monomer having a first ceramic yield,

one or both of a second functionalised organosilicon monomer having a second ceramic yield and a functionalised organic monomer, porous ceramic particles and a porogen.

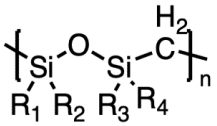
3. The preceramic resin according to claim 1 or 2, wherein the porous ceramic particles are present, and are preferably microporous and/or mesoporous, and wherein at least 90% of the ceramic particles have a size of between about 1 nm to about 1 mm, as determined using TEM.

4. The preceramic resin according to any one of claims 1 to 3, wherein the first functionalised organosilicon monomer is based on an organosilicon monomer independently selected from the group consisting of:

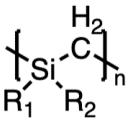
a polysiloxane, polycarbosiloxane, polycarbosilane, polysilylcarbodiimide and a polysilazane having the following chemical structures of Formula 1, Formula 2, Formula 3, Formula 4 and Formula 5, respectively,



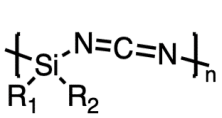
Formula 1



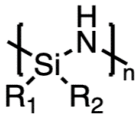
Formula 2



Formula 3



Formula 4



Formula 5

wherein:

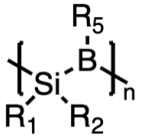
n represents a backbone structure of repeating silicon atom-containing motifs and is independently an integer of from 2 to 15; and

R_1, R_2, R_3 and R_4 are independently selected from the group consisting of H, a C_1-C_{18} substituted or unsubstituted alkyl, a C_1-C_{18} substituted or unsubstituted alkyl ether, a phenyl and a halide, independently for each integer of n, with the proviso that the pairs of R_1 and R_2 and R_3 and R_4 are not both H, alkyl ether or halide for every integer of n, preferably wherein the pairs of R_1 and R_2 and R_3 and R_4 are not both H, alkyl ether or halide for any integer of n, and preferably wherein each of R_1 and R_2 and R_3 and R_4 are identical for

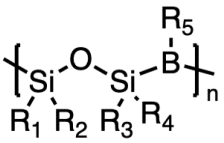
every integer of n;

a polysilsesquioxane, polysilsesquicarbodiimide and a polysilsesquiazane substituted with one or more R_1 groups selected from the group consisting of a C_1-C_{18} substituted or unsubstituted alkyl, a C_1-C_{18} substituted or unsubstituted alkyl ether, a phenyl and a halide; and

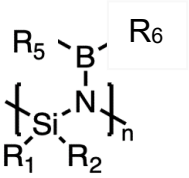
a polyborosilane, a polyborosiloxane and a polyborosilazane having the following chemical structures of Formula 6, Formula 7 and Formula 8, respectively,



Formula 6



Formula 7



Formula 8

wherein:

n represents a backbone structure of repeating silicon atom-containing motifs and is independently an integer of from 2 to 15;

R_1, R_2, R_3 and R_4 are as defined above; and

R_5 and R_6 are independently selected from the group consisting of H, OH, a C_1-C_{18} substituted or unsubstituted alkyl, a C_1-C_{18} substituted or unsubstituted alkyl ether and a phenyl, independently for each integer of n, and preferably wherein R_5 and R_6 are identical for every integer of n.

5. The preceramic resin according to any one of claims 1 to 4, wherein the first functionalised organosilicon monomer is functionalised with a thermal- and/or photopolymerisable functional group.

6. The preceramic resin according to any one of claims 1 to 5, wherein the first functionalised organosilicon monomer is selected from the group consisting of methacryloxypropyl terminated polydimethylsiloxane, (mercaptopropyl) methylsiloxane homopolymer and vinylmethoxysiloxane homopolymer.

7. The preceramic resin according to any one of claim 1 to 6, wherein the second functionalised organosilicon monomer is present and contains a polymerisable functional group that is different from, though complementary to, a polymerisable

functional group of the first functionalised organosilicon monomer.

8. The preceramic resin according to any one of claims 1 to 7, wherein the second functionalised organosilicon monomer is present and wherein the first ceramic yield and the second ceramic yield differ by about 5% or more.

9. The preceramic resin according to any one of claims 1 to 8, wherein the second functionalised organosilicon monomer is present and is selected from the group consisting of methacryloxypropyl terminated polydimethylsiloxane, (mercaptopropyl) methylsiloxane homopolymer, vinylmethoxysiloxane homopolymer and methacryloxypropyl substituted poly(isobutyl-t8-silsesquioxane).

10. The preceramic resin according to any one of claims 1 to 9, wherein the functionalised organic monomer is present and has the following formula:

$$Spacer(L)_n$$

wherein Spacer is a spacer group, L is a reactive group reactive with at least the first functionalised organosilicon monomer, and n is an integer of greater than or equal to 2, preferably wherein n is an integer of from 2 to 4, and is preferably 2.

11. The preceramic resin according to claim 10, wherein the functionalised organic monomer is selected from the group consisting of ethylene glycol diacrylate, poly ethylene glycol diacrylate, ethylene glycol dithiol, polyethylene glycol dithiol, ethylene glycol divinyl ether, polyethylene glycol divinyl ether, ethylene glycol diallyl ether, and polyethylene glycol diallyl ether.

12. The preceramic resin according to any one of claims 1 to 11, wherein the porogen is present and is selected from the group consisting of toluene, methanol, cyclohexanol, hexane, dodecanol, 1,2-popanediol, water, 1-propanol, 1,4-butandiol, dimethylformamide, acetonitrile, decane and decanol, polyethylene glycol (PEG), and polyethylene glycol diacrylate (PEGDA).

13. A porous polymer-derived ceramic material formed from a preceramic resin according to any one of claims 1 to 12.

14. The porous polymer-derived ceramic material according to claim 13, characterised by a specific surface area of greater than or equal to 70 m^2/g.

15. The porous polymer-derived ceramic material according to claim 13, wherein the porous polymer-derived ceramic material is micro-, meso- and/or macroporous.

16. A method for forming a porous polymer-derived ceramic material, said method comprising:

a) subjecting a preceramic resin for forming a porous polymer-derived ceramic material to polymerising conditions to form a preceramic polymer; and

b) subjecting the preceramic polymer to pyrolytic conditions,

wherein formation of the polymer-derived ceramic material from the preceramic polymer proceeds through a porous phase, and wherein the pyrolytic conditions are characterised by a maximum temperature within the porous phase.

17. The method according to claim 16, wherein the method is for forming a porous polymer-derived silica ceramic material, wherein the pyrolytic conditions are characterised by the presence of oxygen,

and wherein the preceramic resin comprises:

a) a first functionalised polycarbosiloxane or polycarbosilane monomer having a first ceramic yield; and

b) one or more of:

i. a second functionalised organosilicon monomer having by a second ceramic yield;

ii. porous ceramic particles; and

iii. a porogen.

18. The method according to claim 16 or 17, wherein the pyrolytic conditions comprise a maximum temperature of no greater than 900 ^oC, and preferably pyrolysis is

performed between minimum and maximum temperatures of 300 ºC and 900 ºC, preferably 400 ºC and 700 ºC.

19. The method according to any one of claims 16 to 18, wherein the pyrolytic conditions comprise a temperature ramp-up rate of no greater than 10 ºC/minute for a period within the porous phase or for a period within the temperature range of 200 to 900 ºC.

20. The method according to any one of claims 16 to 19, further comprising a preliminary step of shaping the preceramic resin using a 3D printer.