CLAIMS

1. A random copolymer of structure (A) comprising,

a carboxylic acid bearing repeat unit of structure **(I),** wherein R_{m1} is H or a C-1 to C-4 alkyl, and n1 is the total number of this repeat unit; wherein this repeat unit ranges from 1.0 mole % to 5.0 mole % in said copolymer;

a 4-vinylbenzocyclobutene derived repeat unit of structure **(II),** wherein R_{m2} is H or a C-1 to C-4 alkyl, and n2 is the total number of this repeat unit; wherein this repeat unit ranges from 5.0 mole % to 35.0 mole % in said copolymer;

a styrenic repeat unit of structure **(III)**, wherein R_{m3} is H or a C-1 to C-4 alkyl, R_{sty} is selected from a H, a C-2 to C-8 linear alkyl, and a C-1 to C-4 alkyloxy and n3 is the total number of this repeat units; wherein this repeat unit ranges from 25 mole % to 94 mole % in said copolymer;

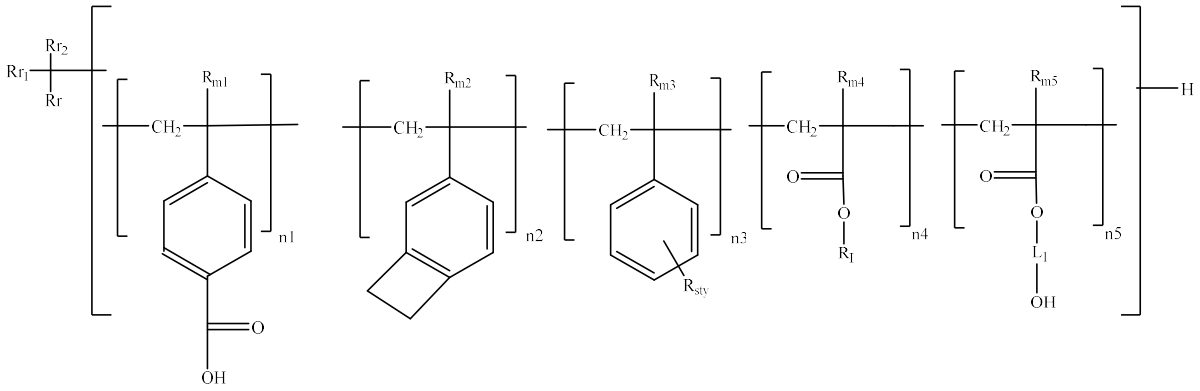
an alkyl acrylate or alkyl 2-methylenealkanoate derived repeat unit of structure (IV), wherein R_{m4} is H or a C-1 to C-4 alkyl, R_I is a C-1 to C-8 alkyl and n4 is the total number of this repeat unit, wherein this repeat unit ranges from 0 mole % to 64 mole % in said copolymer;

a hydroxy functionalized alkyl acrylate or alkyl 2-methylenealkanoate derived repeat unit of structure **(V),** wherein R_{m5} is H or a C-1 to C-4 alkyl, L_1 is a C-2 to C-8 alkylene moiety and n5 is the total number of this repeat unit, wherein this repeat unit ranges from 0 mole % to 3 mole % in said copolymer, and

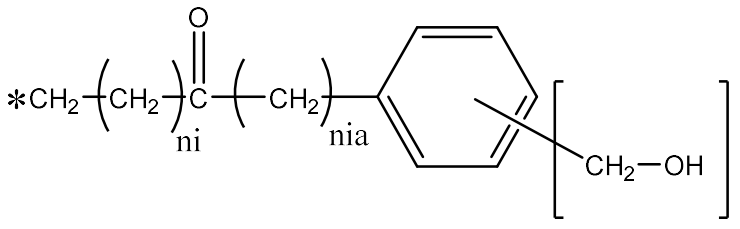
two end groups as shown in structure (A) one of which is H and the other is a methyl moiety substituted with Rr, Rr_1 and Rr_2, wherein Rr_1, is a C-1 to C-8 alkyl, Rr_2 is selected from a C-1 to C-8 alkyl, a C-1 to C-8 alkylene hydroxy moiety (-alkylene-OH), a C-1 -C-8 alkylenecarboxylic acid moiety (-alkylene-CO_2H), or a benzylic alcohol comprising moiety of structure (B) wherein ni is an integer ranging from 0 to 5, nia is an integer from 1 to 5, nib is an integer from 1 to 5, and "*" designates the attached point of this moiety,

Rr is a cyano moiety (-CN) or a carbonylalkyl moiety (-C(=O)-Ri), wherein Ri is a C-1 to C-8 alkyl or an aryl moiety; and further

wherein the sum of the individual mole % of repeat units of structure (I), (II), (III), (IV) and (V), is either smaller than or equal to 100 mole % of the total repeat units present in said copolymer:



(I) (II) (III) (IV) (V) **(A)**



(B).

2. The copolymer of claim 1 wherein a styrenic repeat unit of structure **(III)**, ranges from 30.0 mole % to 94.0 mole % in said copolymer; and said alkyl acrylate or alkyl 2-methylenealkanoate derived repeat unit of structure (IV), ranges from 0 mole % to 45 mole %.

3. The copolymer of claim 1 or 2, whose repeat units consist of the repeat units of structure (I), (II) and (III), wherein

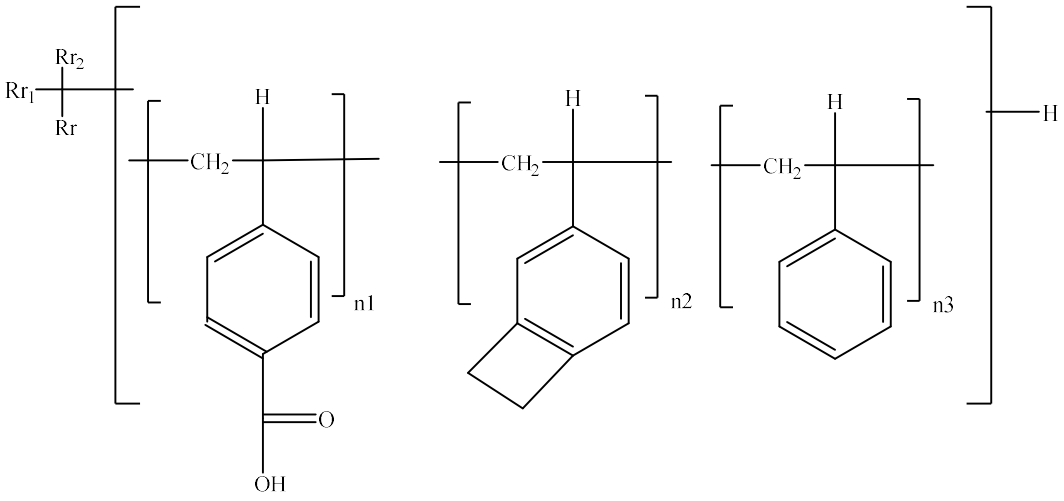
said repeat unit of structure (I) ranges from 1 mole% to 5 mole %,

said repeat unit of structure (II) ranges from 5 mole % to 9 mole %,

said repeat unit of structure (III) ranges from 90 mole % to 94 mole %, and further where the sum of individual mole % for the repeat units of structures (I), (II) and (III) equals 100 mole % of the total repeat units in said copolymer.

4. The copolymer of any one of claims 1 to 3, wherein R_{sty} is H.

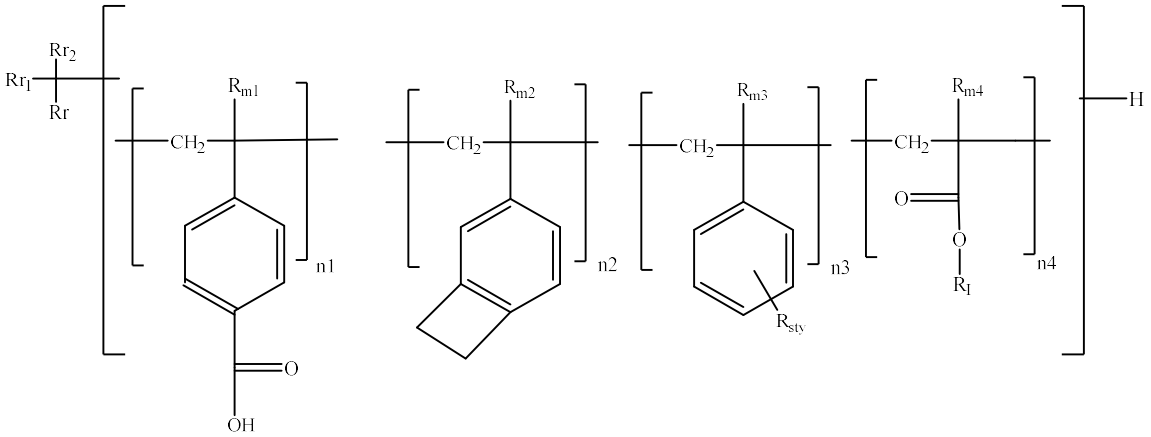
5. The copolymer of any one of claim 1 to 4, wherein said copolymer has structure (A-1),



(Ia) (IIa) (IIIb) (A 1).

6. The copolymer of any one of claims 1 to 5, wherein Rr_2 is a C-1 to C-8 alkylene hydroxy moiety a C-1 to C-8 alkylenecarboxylic acid moiety or a benzylic alcohol comprising moiety of structure (B).

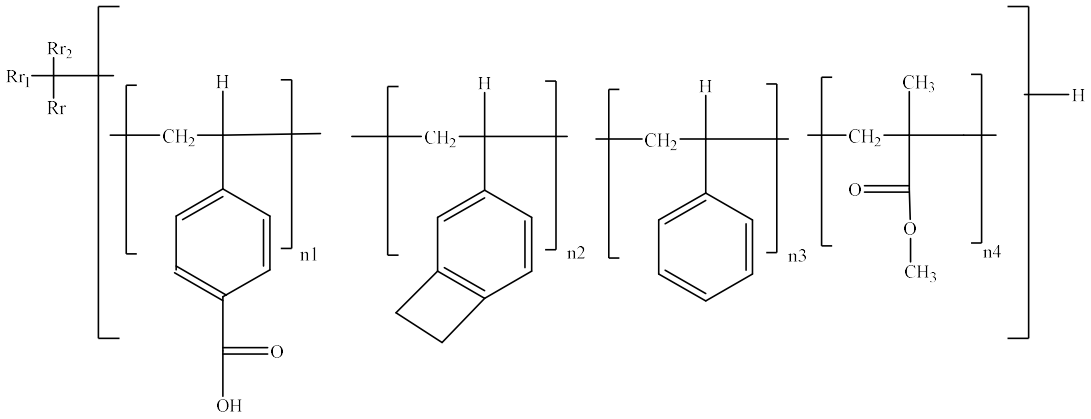
7. The copolymer of claim 1, 4 or 6, which has structure (A-2), wherein
said repeat unit of structure (I) ranges from 1 mole % to 5 mole %,
said repeat unit of structure (II) ranges from 15 mole % to 35 mole %~~,~~
said repeat unit of structure (III) ranges from 25 mole % to 69 mole %, and
said repeat unit of structure (IV) ranges from 5 mole % to 49 mole %,



(I) (II) (III) (IV) (A-2).

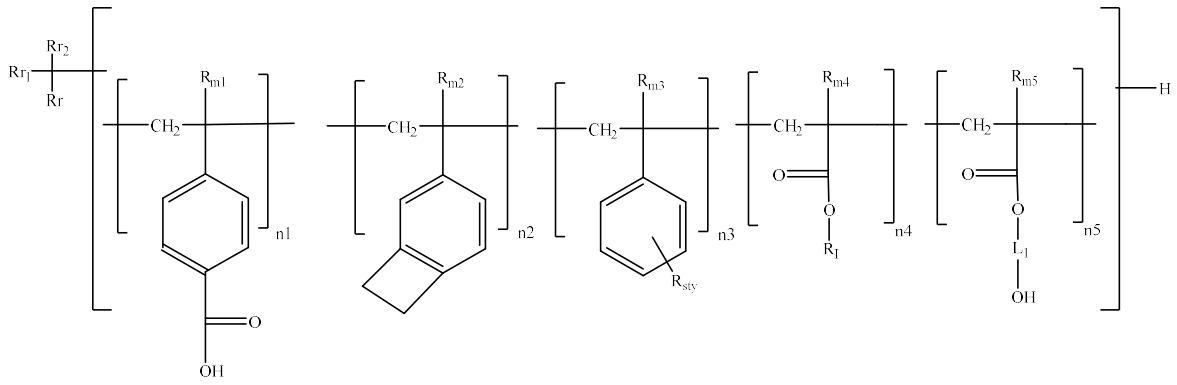
8. The copolymer of claim 7, whose repeat units consist of the repeat units of structure (I), (II), (III) and (IV).

9. The copolymer of claim 7 or 8, wherein said copolymer has structure (A-3),



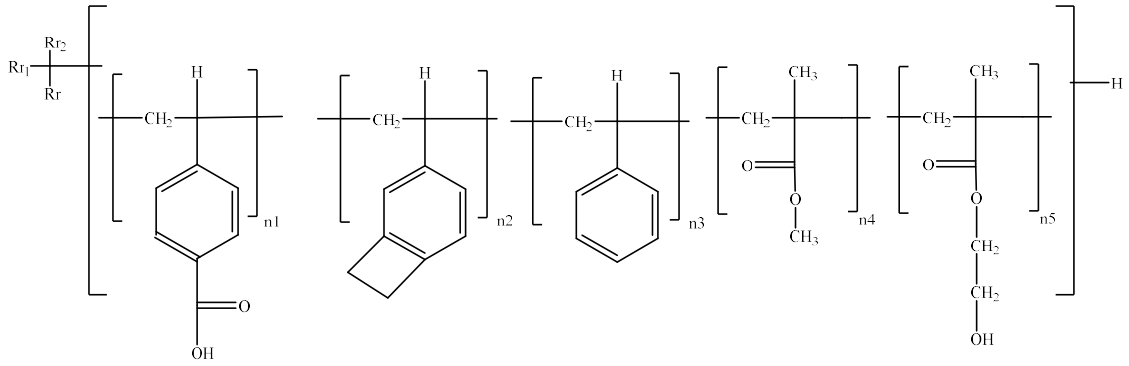
(I) (II) (III) (IV) (A-3).

10. The copolymer of claim 1, 2, 4 or 6, which has structure (A), wherein
said repeat unit of structure (I) ranges from 1 mole % to 5 mole %,
said repeat unit of structure (II) ranges from 15 mole % to 35 mole %,
said repeat unit of structure (III) ranges from 30 mole % to 60 mole %.
said repeat unit of structure (IV) ranges from 15 mole % to 45 mole %,
said repeat unit of structure (V) ranges from 1 mole % to 3 mole %,



(I) (II) (III) (IV) (V) **(A)**

11. The copolymer of claim 10, wherein said copolymer has structure (A-4),



(I) (II) (III) (IV) (V) (A-4).

12. A composition comprising a copolymer of any one of claims 1 to 11 and an organic spin casting solvent.

13. A process for forming a crosslinked or grafted and cross-linked coating of a copolymer on a substrate comprising the steps:

i) forming a coating of a composition of claim 12 on a substrate,

ii) heating the coating at a temperature from 90°C to 180°C to remove solvent and to form a crosslinked or a grafted and crosslinked coating of the copolymer,

iii) heating the crosslinked or a grafted and crosslinked coating of step ii) from 200°C to 250°C to form a fully cross-linked or fully crosslinked and grafted copolymer coating.

14. The process of claim 13, wherein

a) the process is for forming a cross-linked or grafted and crosslinked non-polar pinning coating on a substrate, wherein the composition of claim 12 comprises the copolymer of any one of claims 1 to 6 whose repeat units consist of the repeat units of structure (I), (II) and (III); or

b) the process is for forming a crosslinked non-polar pinning coating on a substrate, wherein the composition of claim 12 comprises the copolymer of any one of claims 1 to 5, wherein Rr_2 is a C-1 to C-8 alkyl; or

c) the process is for forming a cross-linked or grafted and crosslinked neutral coating on a substrate, wherein the composition of claim 12 comprises the copolymer of any one of claims 7 to 9; or

d) the process is for forming a grafted and crosslinked neutral coating on a substrate, wherein the composition of claim 12 comprises the copolymer of any one of claims 7 to 9, where Rr_2 is a C-1 to C-8 alkylene hydroxy moiety, a C-1 to C-8 alkylenecarboxylic acid moiety or a benzylic alcohol comprising moiety of structure (B); or

e) the process is for forming a crosslinked neutral coating on a substrate, wherein the composition of claim 12 comprises the copolymer of any one of claims 7 to 9, where Rr_2 is a C-1 to C-8 alkyl; or

f) the process is for forming a cross-linked or grafted and crosslinked neutral coating on a substrate, wherein the composition of claim 12 comprises the copolymer of claim 10 or 11; or

g) the process is for forming a grafted and crosslinked neutral coating on a substrate, wherein the composition of claim 12 comprises the copolymer of claim 10 or 11, wherein Rr_2 is a C-1 to C-8 alkylene hydroxy moiety, a C-1 to C-8 alkylenecarboxylic acid moiety or a benzylic alcohol comprising moiety of structure (B); or

h) the process is for forming a crosslinked neutral coating on a substrate, wherein the composition of claim 12 comprises the copolymer of claim 10 or 11, wherein Rr_2 is a C-1 to C-8 alkyl.

15. A process for forming a self-assembled block copolymer coating on a neutral coating comprising the steps:

ij) forming neutral coating according to d), e), f), g) or h) of claim 14,

iij) applying a block copolymer over the neutral coating and annealing until directed self-assembly of the block copolymer coating occurs.

16. A process of graphoepitaxy, directed self-assembly of a block copolymer coating used to form an image comprising the steps:

ik) forming neutral coating according to d), e), f), g) or h) of claim 14,

iik) providing a coating of a photoresist coating over the neutral coating, and

forming a pattern in the photoresist coating,

iiik) applying a block copolymer comprising an etch resistant block and a highly etchable block over the photoresist pattern and annealing until directed self-assembly occurs; and,

ivk) etching the block copolymer, thereby removing the highly etchable block of the copolymer overcoating areas of the substrate and simultaneously forming a pattern in the substrate selectively in these areas.

17. A process of chemoepitaxy, directed self-assembly of a block copolymer coating used to form an image comprising the steps:

il) forming neutral coating on as substrate according to d), e), f), g) or h) of claim 14,

iil) providing a coating of a photoresist coating over the neutral coating, and

forming a pattern in the photoresist coating, thereby forming regions in which the neutral coating is uncovered by the resist,

iiil) treating the uncovered neutral coating to remove it, forming a pinning area,

ivl) removing the photoresist, uncovering the unaffected neutral coating forming a chemoepitaxy pattern containing neutral and pinning areas,

vl) applying a block copolymer comprising an etch resistant block and a highly etchable block over the neutral coating and annealing until directed self-assembly occurs; and

vil) etching the block copolymer, thereby removing the highly etchable block of the copolymer overcoating areas of the substrate and simultaneously forming a pattern in the substrate selectively in these areas.

18. A process of chemoepitaxy, directed self-assembly of a block copolymer coating used to form an image comprising the steps:

im) forming a non-polar pinning coating on a substrate according to a) or b) of claim 14,

iim) providing a coating of a photoresist coating over pinning coating,

iiim) forming a pattern in the photoresist coating, thereby forming regions in which the pinning coating is uncovered by the resist,

ivm) treating the uncovered pinning coating to remove it, forming a bare substrate areas,

vm) removing the photoresist, uncovering both the unaffected pinning coating and the bare areas of substrate,

vim) applying a neutral coating in the areas of bare substrate forming a chemoepitaxy pattern containing neutral and pinning areas,

viim) applying a block copolymer comprising an etch resistant block and a highly etchable block over the chemoepitaxy pattern and annealing until directed self-assembly occurs; and

viiim) etching the block copolymer, thereby removing the highly etchable block of the copolymer overcoating areas of the substrate and simultaneously forming a pattern in the substrate selectively in these areas.

19. A microelectronic device made using the pattern formed in in any one of claims 16 to 18.

20. The use of the copolymer according to any one of claims 1 to 11 or the composition according to claim 12 in the preparation of a coated substrate or an electronic device.