CLAIMS

1. A method for processing surface of a semiconductor substrate (100), the method being carried out with a cluster apparatus (1) comprising a transport chamber (10) and two or more process reactors (20, 30, 40, 60) connected to the transport chamber (10), the method comprises providing vacuum atmosphere to the transport chamber (10) and the method further comprises the following processing steps carried out successively:

a) subjecting the surface of the substrate (100) to a surface preparation step for providing a prepared substrate surface;

b) providing an interface layer on the prepared substrate surface of the substrate (100) for forming an interfaced substrate surface; and

c) providing a functional layer on the interfaced substrate surface of the substrate (100) for providing a functionally coated substrate,

c h a r a c t e r i z e d in that:

- the step a) comprises pre-cleaning the surface of the substrate (100) by utilizing plasma treatment on the surface of the substrate (100) for providing the prepared substrate surface;

- the step b) comprises depositing the interface layer on the prepared substrate surface by utilizing plasma enhanced deposition method for providing the interfaced substrate layer; and

depositing an AlN –layer on the prepared substrate surface by utilizing plasma enhanced atomic layer deposition method for providing the interfaced substrate layer; or depositing an SiO_2 –layer, Si_3N_4 –layer, Al_2O_3 –layer, TiN –layer, WN –layer, HfO_2 –layer, ZrO_2 –layer, SiC –layer, SiCN –layer, TaC –layer or TiC-layer on the prepared substrate surface by utilizing plasma enhanced atomic layer deposition method for providing the interfaced substrate layer; and

- the step c) comprises depositing the functional layer on the interfaced substrate surface by utilizing atomic layer deposition method for providing the functionally coated substrate surface,

the method further comprises:

- carrying the processing steps a), b) and c) in at least two different process reactors (20, 30, 40, 60) connected to the transport chamber (10); and

- transporting the substrate (100) between the at least two process reactors (20, 30, 40, 60) via the transport chamber (10) under vacuum atmosphere.

2. A method according to claim 1, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out step a) in a first process reactor (20);
- transporting the substrate (100) after step a) from the first process reactor (20) to a second process reactor (30) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps b) and c) in the second process reactor (30); or
- carrying out steps a) and b) in a first process reactor (20);
- transporting the substrate (100) after step b) from the first process reactor (20) to a second process reactor (30, 40) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps c) in the second process reactor (30, 40); or
- carrying out step a) in a first process reactor (20);
- transporting the substrate (100) after step a) from the first process reactor (20) to a second process reactor (30) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the second process reactor (30);
- transporting the substrate (100) after step b) from the second process reactor (30) to a third process reactor (40, 60) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps c) in the third process reactor (40, 60).

3. A method according to claim 1 or 2, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out steps a) and b) in a single substrate reactor (20, 30, 60) and carrying out step c) in a batch process reactor (40); or
- carrying out steps a) in a first single substrate reactor (20), carrying out step b) in a second single substrate reactor (30) and carrying out step c) in a batch process reactor (40); or
- carrying out steps a), b) and a first portion of step c) in a single substrate reactor (20, 30, 60) and carrying out a second portion of step c) in a batch process reactor (40); or
- carrying out steps a) in a first single substrate reactor (20), carrying out step b) in a second single substrate reactor (30), carrying out a first portion of step c) in the second single substrate reactor (30) and carrying out a second portion of step c) in a batch process reactor (40).

4. A method according to any one of claims 1 to 3, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out step a) in the single substrate reactor (20);
- transporting the substrate (100) after step a) from the first single substrate reactor (20) to the second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps b) and c) in the second single substrate reactor (30); or
- carrying out steps a) and b) in the first single substrate reactor (20);
- transporting the substrate (100) after step b) from the first single substrate reactor (20) to the second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps c) in the second single substrate reactor (30); or
- carrying out step a) in the first single substrate reactor (20);
- transporting the substrate (100) after step a) from the first single substrate reactor (20) to the second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the second single substrate reactor (30);
- transporting the substrate (100) after step b) from the second single substrate reactor (30) to a third single substrate reactor (60) via the transport chamber (10) under vacuum atmosphere; and
- carrying out step c) in the third single substrate reactor (60).

5. A method according to any one of claims 1 to 3, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out steps a) and b) in the first single substrate reactor (20);
- transporting the substrate (100) after step b) from the first single substrate reactor (20) to the first batch process reactor (40) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps c) in the first batch process reactor (40); or
- carrying out steps a) and b) in the first single substrate reactor (20);
- carrying out the first portion of step c) in the first single substrate reactor (20) for providing the first portion of the functional layer on the interfaced substrate surface;
- transporting the substrate (100) after the first portion of step c) from the first single substrate reactor (20) to the first batch process reactor (40) via the transport chamber (10) under vacuum atmosphere; and

- carrying out the second portion of step c) in the first batch process reactor (40) for providing the second portion of the functional layer on the first portion of the functional layer.

6. A method according to any one of claims 1 to 3, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out step a) in the first single substrate reactor (20);
- transporting the substrate (100) after step a) from the first single substrate reactor (20) to the second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the second single substrate reactor (30);
- transporting the substrate (100) after step b) from the second single substrate reactor (30) to the first batch process reactor (40) via the transport chamber (10) under vacuum atmosphere; and
- carrying out step c) in the first batch process reactor (40); or
- carrying out step a) in the first single substrate reactor (20);
- transporting the substrate (100) after step a) from the first single substrate reactor (20) to the second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the second single substrate reactor (30);
- carrying out the first portion of step c) in the second single substrate reactor (30) for providing the first portion of the functional layer on the interfaced substrate surface;
- transporting the substrate (100) after the first portion of step c) from the second single substrate reactor (30) to the first batch process reactor (40) via the transport chamber (10) under vacuum atmosphere; and
- carrying out the second portion of step c) in the first batch process reactor (40).

7. A method according to claim 1 or 2, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out step a) in a first batch process reactor (40);
- transporting the substrate (100) after step a) from the first batch process reactor (40) to a first single substrate reactor (20) via the transport chamber (10) under vacuum atmosphere; and
- carrying out steps b) and c) in the first single substrate reactor (20).

8. A method according to claim 1 or 2, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out step a) in a first batch process reactor (40);
- transporting the substrate (100) after step a) from the first batch process reactor (40) to a first single substrate reactor (20) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the first single substrate reactor (20);
- transporting the substrate (100) after step b) from the first single substrate reactor (30) to a second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere; and
- carrying out step c) in the second single substrate reactor (30); or
- carrying out step a) in a first batch process reactor (40);
- transporting the substrate (100) after step a) from the first batch process reactor (40) to a first single substrate reactor (20) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the first single substrate reactor (20);
- carrying out the first portion of step c) in the first single substrate reactor (20) for providing the first portion of the functional layer on the interfaced substrate surface;
- transporting the substrate (100) after the first portion of step c) from the first single substrate reactor (20) to a second single substrate reactor (30) via the transport chamber (10) under vacuum atmosphere; and
- carrying out the second portion of step c) in the second single substrate reactor (30).

9. A method according to claim 1 or 2, **c h a r a c t e r i z e d** in that the method comprises:

- carrying out step a) in a first batch process reactor (40);
- transporting the substrate (100) after step a) from the first batch process reactor (40) to a first single substrate reactor (20) via the transport chamber (10) under vacuum atmosphere;
- carrying out step b) in the first single substrate reactor (20);
- transporting the substrate (100) after step b) from the first single substrate reactor (30) to a second batch process reactor (46) via the transport chamber (10) under vacuum atmosphere; and
- carrying out step c) in the second batch process reactor (46); or
- carrying out step a) in a first batch process reactor (40);

- transporting the substrate (100) after step a) from the first batch process reactor (40) to a first single substrate reactor (20) via the transport chamber (10) under vacuum atmosphere;

- carrying out step b) in the first single substrate reactor (20);

- carrying out the first portion of step c) in the first single substrate reactor (20) for providing the first portion of the functional layer on the interfaced substrate surface;

- transporting the substrate (100) after the first portion of step c) from the first single substrate reactor (20) to a second batch process reactor (46) via the transport chamber (10) under vacuum atmosphere; and

- carrying out the second portion of step c) in the second batch process reactor (46).

10. A method according to any one or claims 5 to 9, **c h a r a c t e r i z e d** in that:

- step a) comprises subjecting the surface of two or more substrates (100) simultaneously to the surface preparation step in the first batch process reactor (40); or

- step c) comprises providing the functional layer or the second portion of the functional layer to two or more substrates (100) simultaneously in the first batch process reactor (40) or in the second batch process reactor (46); or

- step a) comprises subjecting the surface of two or more substrates (100) simultaneously to the surface preparation step in the first batch process reactor (40); and

- step c) comprises providing the functional layer or the second portion of the functional layer to two or more substrates (100) simultaneously in the second batch process reactor (46).

11. A method according to any one of claims 1 to 10, **c h a r a c t e r i z e d** in that step a) comprises:

- pre-cleaning the surface of the substrate (100) by NH3 –plasma processing for providing the prepared substrate surface;

- pre-cleaning the surface of the substrate (100) by plasma processing utilizing N_2 –plasma, O_2 –plasma, Ar –plasma, H_2 –plasma, CO –plasma, CO_2 –plasma or a mixture thereof for providing the prepared substrate surface.

12. A method according to any one of claims 1 to 11, **c h a r a c t e r i z e d** in that step c) comprises:

- depositing the functional layer on the interfaced substrate surface by utilizing thermal atomic layer deposition method for providing the functionally coated substrate surface.

13. A method according to any one of claims 1 to 12, **c h a r a c t e r i z e d** in that the method is applied to a semiconductor substrate, compound semiconductor substrate, or group iii-v semiconductor substrate.

14. A method according to any one of claims 1 to 13, **c h a r a c t e r i z e d** in that the method is carried out with an apparatus according to the any one of claims 15 to 21.

15. A cluster apparatus for processing surface of a substrate (100), the cluster apparatus (1) comprises a transport chamber (10), a vacuum device (12) connected to the transport chamber (10) for providing vacuum atmosphere inside the transport chamber (10), a transport robot (16) arranged inside the transport chamber (10), two or more process reactors (20, 30, 40, 60) connected to the transport chamber (10), the two or more process chambers (20, 30, 40, 60) comprise a first singe substrate process reactor (20) arranged to receive one substrate (100), and a first batch process reactor (40) arranged to receive two or more substrates (100), **c h a r a c t e r i z e d** in that:

- the first single substrate reactor (20) is an atomic layer deposition reactor having a reaction chamber (80) and comprises plasma electrodes (84, 86) arranged to generate plasma inside the reaction chamber (80);

- the first batch reactor (40) is an atomic layer deposition reactor having a reaction chamber (90) and a substrate rack (93) arranged to support two or more substrates (100).

16. A cluster apparatus according to claim 15, **c h a r a c t e r i z e d** in that the two or more process chambers (20, 30, 40, 60) further comprise a second single substrate reactor (30) arranged to receive one substrate (100).

17. A cluster apparatus according to claim 15 or 16, **c h a r a c t e r i z e d** in that:

- the first single substrate reactor (20) comprises single substrate

support (81) arranged to support one substrate (100);

- the first single substrate reactor (20) comprises single substrate support (81) arranged to support one substrate (100), and the second single substrate reactor (30) comprises single substrate support (81) arranged to support one substrate (100).

18. A cluster apparatus according to any one of claims 15 to 17, **c h a r a c t e r i z e d** in that the two or more process chambers (20, 30, 40, 60) further comprise a second batch process reactor (46) arranged to receive two or more substrates (100).

19. A cluster apparatus according to any one of claims 15 to 18, **c h a r a c t e r i z e d** in that:

- the first batch process reactor (40) comprises a substrate rack (93) arranged to support two or more substrates (100); or

- the first batch process reactor (40) comprises a substrate rack (93) arranged to support two or more substrates (100) and the second batch process reactor (46) comprises a substrate rack (93) arranged to support two or more substrates (100).

20. A cluster apparatus according to any one of claims 15 to 19, **c h a r a c t e r i z e d** in that:

- the second single substrate reactor (30) is an atomic layer deposition reactor having a reaction chamber (80) and comprises plasma electrodes (84, 86) arranged to generate plasma inside the reaction chamber (80).

21. A cluster apparatus according to any one of claims 15 to 20, **c h a r a c t e r i z e d** in that_

- the second batch reactor (46) is an atomic layer deposition reactor having a reaction chamber (90) and the substrate rack (93) arranged to support two or more substrates (100).