## CLAIMS

1. An apparatus for treating a surface of a substrate, comprising:

a substrate support configured to support the substrate;

a proximity head configured to dispense a treatment gas to treat an active process region of a substrate surface under the proximity head, wherein the proximity head covers the action process region of the substrate surface and the proximity head includes at least one vacuum channel to pull excess treatment gas from a reaction volume between the proximity head and the substrate, the proximity head having an excitation chamber to excite the treatment gas before the treatment gas being dispensed on the active process region portion of the substrate surface.

2. The apparatus of claim 1, wherein there are two vacuum channels, one on each side of at least one gas channel to dispense the treatment gas.

3. The apparatus of claim 1, wherein there is one vacuum channel surrounding at least one gas channel to dispense the treatment gas.

4. The apparatus of claim 1, wherein the treatment gas is selected form a group consisting of $H_2$, $NH_3$, $NF_3$, $NH_4F$, $O_2$, and $N_2$.

5. The apparatus of claim 4, wherein the treatment gas is diluted by an inert gas.

6. The apparatus of claim 1, wherein the treatment gas is excited by a hot-filament, by laser, by ultra-violent (UV), or by plasma.

7. A method of treatment a substrate surface, comprising:

moving a proximity head for surface treatment above a substrate, wherein the proximity head has at least one gas channel configured to dispense a treatment gas on a region of the substrate surface, the proximity head having at least one vacuum channel used to vacuum excess treatment gas from a reaction volume underneath the proximity head, and the proximity head for surface treatment covering the region of the substrate surface;

exciting the treatment gas in an excitation chamber of the proximity head before the treatment gas is dispensed on the region of the substrate surface; and

dispensing the excited treatment gas on the region of the substrate surface to treat the substrate surface.

8. The method of claim 7, wherein the surface treatment is used to remove surface impurities prior to the deposition of a film on the substrate.

9. The method of claim 7, wherein the surface treatment is used to increase initial deposition sites for an ALD of a barrier layer for copper.

10. The method of claim 7, wherein the surface treatment is performed on a deposited liner layer to enhance nucleation for an electroless copper seed layer to be deposited, or to remove contaminants on the deposited liner layer prior to the deposition of a copper seed layer.

11. A chamber for performing surface treatment and film deposition, comprising:

a first proximity head for substrate surface treatment configured to dispense a first treatment gas to treat a portion of a surface of a substrate under the first proximity head for substrate surface treatment; and

a first proximity head for atomic layer deposition (ALD) configured to sequentially dispensing a first reactant gas and a first purging gas to deposit a first ALD film under the second proximity head for ALD.

12. The apparatus of claim 11, further comprising:

a second proximity head for substrate surface treatment configured to dispense a second treatment gas to treat a portion of the surface of the substrate under the first proximity head for substrate surface treatment; and

a second proximity head for ALD configured to sequentially dispensing a second reactant gas and a second purging gas to deposit a second ALD film under the second proximity head for ALD.

13. The apparatus of claim 11, wherein the first proximity head for substrate surface treatment is used to perform a surface treatment before or after the substrate is deposited with the first ALD film.

14. The apparatus of claim 11, wherein the first ALD film is a barrier layer for copper.

15. The apparatus of claim 12, wherein the second ALD film is a liner layer for copper.

16. The apparatus of claim 12, wherein the second proximity head for substrate surface treatment is used to perform a surface treatment after the substrate is deposited with the second ALD film.

17. The apparatus of claim 12, wherein the first proximity head for ALD is placed next to the first proximity head for substrate surface treatment, the second proximity head for ALD being placed next to the first proximity head for ALD, and the second proximity head for substrate surface treatment being placed next to the second proximity head for ALD.

18. The apparatus for claim 17, wherein the first proximity head for substrate surface treatment is used to perform a pre-treatment before film deposition on the substrate, the first proximity head for ALD being used to deposit a barrier layer for copper, the second proximity head for ALD being used to deposit a liner layer for copper, and the second proximity head for substrate surface treatment being used to perform a post-treatment after the barrier layer and the liner layer being deposited.

19. The apparatus of claim 11, wherein the first reactant gas is a barrier-metal-containing reactant or a reactant gas that form a barrier layer with the barrier-metal-containing reactant.

20. The apparatus of claim 12, wherein the second reactant gas is a liner-metal-containing reactant or a reactant gas that form a liner layer with the liner-metal-containing reactant.

21. A method of performing surface treatment and film deposition on a substrate in a processing chamber, comprising:

placing the substrate in the processing chamber with a plurality of proximity heads for surface treatment and film deposition, wherein each of the plurality of proximity head covers a portion of a substrate surface;

moving a pre-treatment proximity head above a region on the substrate surface;

performing a surface pre-treatment with the pre-treatment proximity head at the region on the substrate surface;

moving an atomic layer deposition 1 (ALD1) proximity head above the region on the substrate surface; and

depositing a barrier layer for copper with the ALD 1 proximity head at the region on the substrate surface.

22. The method of claim 21, further comprising:

moving an atomic layer deposition 2 (ALD2) proximity head above the region on the substrate surface;

depositing a liner layer for copper with the ALD2 proximity head at the region on the substrate surface;

moving a post-treatment proximity head above a region on the substrate surface; and

performing a surface post-treatment with the post-treatment proximity head at the region on the substrate surface.

23. The method of claim 21, wherein the surface pre-treatment is used to remove surface impurities prior to the deposition of the barrier layer or to increase initial deposition sites for the barrier layer deposited with ALD1 proximity head.

24. The method of claim 22, wherein the surface post-treatment is performed on the liner layer for copper to enhance nucleation for an electroless copper seed layer to be deposited.

25. The method of claim 21, wherein the surface pre-treatment and the barrier layer deposition are performed in the same chamber to reduce process time and to protect the pre-treated substrate surface from being contaminated or being non-active before the barrier layer is deposited.

26. A method of depositing films on a substrate for copper interconnect in an integrated system, comprising:

moving the substrate into a processing chamber having a plurality of proximity heads, selected ones of the proximity heads being configured to perform at least one of surface treatments and atomic layer depositions (ALDs), the processing chamber being part of the integrated system, and within the processing chamber, performing,

barrier layer deposition over a surface of the substrate using one of the plurality of proximity heads functioning to perform barrier layer ALD; and

moving the substrate from the processing chamber, through a transfer module of the integrated system and into a processing module for performing copper seed layer deposition, the processing module for performing copper seed layer deposition being part of the integrated system, and within the processing module for performing copper seed layer deposition, performing,

copper seed layer deposition over the surface of the substrate,

wherein the integrated system enables controlled-ambient transitions within the integrated system to limit exposure of the substrate to uncontrolled ambient conditions outside of the integrated system.

27. The method of claim 26, further comprising:

moving the substrate from the processing module for performing copper seed layer deposition, through the transfer module of the integrated system and into a processing module for performing copper gap-fill layer deposition, the processing module for performing copper gap-fill layer deposition being part of the integrated system, and within the processing module for performing copper gap-fill layer deposition, performing,

copper gap-fill layer deposition over the copper seed layer of the substrate; and

moving the substrate from the processing module for performing copper gap-fill layer deposition, through the transfer module of the integrated system and into a processing module for performing substrate cleaning, the processing module for performing substrate cleaning being part of the integrated system, and within the processing module for substrate cleaning, performing,

cleaning of the substrate after the copper gap-fill layer deposition has been performed.

28. The method of claim 26, further comprising:

performing surface pre-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface pre-treatment in the processing chamber before the barrier layer deposition.

29. The method of claim 28, wherein the surface pre-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate for the barrier layer deposition.

30. The method of claim 28, further comprising:

performing liner layer deposition over the barrier layer of the substrate using one of the plurality of proximity heads functioning to perform liner layer ALD in the processing chamber, and

performing surface post-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface post-treatment in the processing chamber after the liner layer deposition.

31. The method of claim 30, wherein the surface post-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate in preparation for the copper seed layer deposition.

32. The method of claim 26, wherein the films deposited on the substrate for copper interconnect in the integrated system with limited exposure to uncontrolled ambient conditions outside the integrated system improve electro-migration (EM) performance for copper interconnect.

33. An integrated system for depositing films on a substrate for copper interconnect, comprising:

a processing chamber having a plurality of proximity heads, selected ones of the proximity heads being used for surface treatments and atomic layer depositions (ALDs);

a vacuum transfer module coupled to the processing chamber, the vacuum transfer module being used to transfer the substrate in the integrated system;

a processing module for copper seed layer deposition;

a controlled-ambient transfer module coupled to the processing module for copper seed layer deposition; and

a loadlock coupled to the vacuum transfer module and to the controlled-ambient transfer module, the loadlock being used to assist transferring the substrate between the vacuum transfer module and to the controlled-ambient transfer module, wherein the integrated system enables controlled-ambient transitions within the integrated system to limit exposure of the substrate to uncontrolled ambient conditions outside of the integrated system.

34. The integrated system of claim 33, further comprising:

a processing module for copper gap-fill layer deposition, which is coupled to the controlled-ambient transfer module; and

a processing module for substrate cleaning, which is coupled to the controlled-ambient transfer module.

35. The integrated system of claim 33, further comprising:

a cassette for holding the substrate before and after the substrate being processed in the integrated system; and

a loadlock coupled to the cassette and to the vacuum transfer module, the loadlock being used to assist transferring the substrate between the cassette and the vacuum transfer module.

36. The integrated system of claim 33, wherein one of the proximity heads is used to deposit an ALD barrier layer for copper interconnect.

37. The integrated system of claim 33, wherein one of the proximity heads is used to deposit an ALD liner layer for copper interconnect.

38. The integrated system of claim 33, wherein one of the proximity heads is used to perform surface pre-treatment before ALDs, and another one of the proximity heads is used to perform surface post-treatment after ALDs.

39. The integrated system of claim 33, wherein the selected ones of the proximity heads includes a proximity head for surface pre-treatment, a proximity head for barrier layer ALD, a proximity head for liner layer ALD, and a proximity head for surface post-treatment.

40. The method of claim 33, wherein the controlled-ambient transfer module and the processing module for performing copper seed layer deposition are filled with an inert gas to limit the exposure of the substrate to oxygen.

What is claimed is:

1. A method of depositing films on a substrate for copper interconnect in an integrated system, comprising:

moving the substrate into a processing chamber having a plurality of proximity heads, selected ones of the proximity heads being configured to perform at least one of surface treatments and atomic layer depositions (ALDs), the processing chamber being part of the integrated system, and within the processing chamber, performing, barrier layer deposition over a surface of the substrate using one of the plurality of proximity heads functioning to perform barrier layer ALD; and

moving the substrate from the processing chamber, through a transfer module of the integrated systems, into a processing module for performing copper seed layer deposition, the processing module for performing copper seed layer deposition being part of the integrated system, wherein the processing module for performing copper seed layer deposition is integrated with a rinse/dryer to enable dry-in/dry-out process capability limiting the exposure of the substrate to oxygen, and within the processing module for performing copper seed layer deposition, performing, copper seed layer deposition over the surface of the substrate,

wherein the integrated system enables controlled-ambient transitions within the integrated system to limit exposure of the substrate to uncontrolled ambient conditions outside of the integrated system.

2. The method of claim 1, further comprising:

moving the substrate from the processing module for performing copper seed layer deposition, through the transfer module of the integrated system, into a processing module for performing copper gap-fill layer deposition, the processing module for performing copper gap-fill layer deposition being part of the integrated, system, and within the processing module for performing copper gap-fill layer deposition, performing, copper gap-fill layer deposition over the copper seed layer of the substrate; and

moving the substrate from the processing module for performing copper gap-fill layer deposition, through the transfer module of the integrated system and into a processing module for performing substrate cleaning, the processing module for performing substrate cleaning being part of the integrated system, and within the processing module for substrate cleaning, performing, cleaning of the substrate after the copper gap-fill layer deposition has been performed.

3. The method of claim 2, wherein the processing module for performing copper gap-fill layer deposition is an electrochemical plating (ECP) module.

4. The method of claim 1, further comprising:

performing surface pre-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface pre-treatment in the processing chamber before the barrier layer deposition.

5. The method of claim 4, wherein the surface pre-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate for the barrier layer deposition.

6. The method of claim 4, further comprising:

performing liner layer deposition over the barrier layer of the substrate using one of the plurality of proximity heads functioning to perform liner layer ALD in the processing chamber, and

performing surface post-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface post-treatment in the processing chamber after the liner layer deposition.

7. The method of claim 6, wherein the surface post-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate in preparation for the copper seed layer deposition.

8. The method of claim 6, wherein substrate processing on substrate is performed in the sequence of surface pre-treatment, barrier layer deposition, liner layer deposition, and surface post-treatment.

9. The method of claim 6, the metals in the barrier layer and the liner layer are selected from the group consisting of tantalum (Ta), titanium (Ti), tungsten (W), zirconium (Zr), hafnium (HD, molybdenum (Mo), niobium (Nb), vanadium (V), ruthenium (Ru) and chromium (Cr).

10. The method of claim 1, wherein the processing module for performing copper seed layer deposition is an electroless deposition (ELD) module.

11. The method of claim 1, wherein the transfer module and the processing module for performing copper seed layer deposition are filled with an inert gas to limit the exposure of the substrate to oxygen.

12. The method of claim 1, wherein the films deposited on the substrate for copper interconnect in the integrated system with limited exposure to uncontrolled ambient conditions outside the integrated system improve electro-migration (EM) performance for copper interconnect.

13. The method of claim 1, wherein the barrier layer deposited is conformal and reduces void formation in copper interconnect.

14. A method of depositing films on a substrate for copper interconnect in an integrated system, comprising:

moving the substrate into a processing chamber having a plurality of proximity heads, selected ones of the proximity heads being configured to perform at least one of surface treatments and atomic layer depositions (ALDs), the processing chamber being part of the integrated system, and within the processing chamber, performing, surface pre-treatment over a surface of the substrate using one of the plurality of proximity heads functioning to perform surface pre-treatment in the processing chamber before a barrier layer deposition, wherein the surface pre-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate for the barrier layer deposition, and barrier layer deposition over the surface of the substrate using one of the plurality of proximity beads functioning to perform barrier layer ALD after surface pre-treatment; and

moving the substrate from the processing chamber, through a transfer module of the integrated system, into a processing module for performing copper seed layer deposition, the processing module for performing copper seed layer deposition being part of the integrated system, wherein the processing module for performing copper seed layer deposition is integrated with a rinse/dryer to enable dry-in/dry-out process capability limiting the exposure of the substrate to oxygen, and within the processing module for performing copper seed layer deposition, performing, copper seed layer deposition over the surface of the substrate,

wherein the integrated system enables controlled-ambient transitions within the integrated system to limit exposure of the substrate to uncontrolled ambient conditions outside of the integrated system.

15. The method of claim 14, further comprising:

moving the substrate from the processing module for performing copper seed layer deposition, through the transfer module of the integrated system and into a processing module for performing copper gap-fill layer deposition, the processing module for performing copper gap-fill layer deposition being part of the integrated system, and within the processing module for performing copper gap-fill layer deposition, performing, copper gap-fill layer deposition over the copper seed layer of the substrate; and

moving the substrate from the processing module for performing copper gap-fill layer deposition, through the transfer module of the integrated system, into a processing module for performing substrate cleaning, the processing module for performing substrate cleaning being part of the integrated system, and within the processing module for substrate cleaning, performing, cleaning of the substrate after the copper gap-fill layer deposition has been performed.

16. The method of claim 14, further comprising:

performing liner layer deposition over the barrier layer of the substrate using one of the plurality of proximity heads functioning to perform liner layer ALD in the processing chamber, and

performing surface post-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface post-treatment in the processing chamber after the liner layer deposition, wherein the surface post-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate in preparation for the copper seed layer deposition.

17. The method of claim 16, wherein substrate processing on substrate is performed in the sequence of surface pre-treatment, barrier layer deposition, liner layer deposition, and surface post-treatment.

18. The method of claim 14, wherein the transfer module and the processing module for performing copper seed layer deposition are filled with an inert gas to limit the exposure of the substrate to oxygen.

19. A method of depositing films on a substrate for copper interconnect in an integrated system, comprising:

moving the substrate into a processing chamber having a plurality of proximity heads, selected ones of the proximity heads being configured to perform at least one of surface treatments and atomic layer depositions (ALDs), the processing chamber being part of the integrated system, and within the processing chamber, performing, barrier layer deposition over a surface of the substrate using one of the plurality of proximity heads functioning to perform barrier layer ALD, surface pre-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface pre-treatment in the processing chamber before the barrier layer deposition, liner layer deposition over the barrier layer of the substrate using one of the plurality of proximity heads functioning to perform liner layer ALD in the processing chamber, and surface post-treatment over the surface of the substrate using one of the plurality of proximity heads functioning to perform surface post-treatment in the processing chamber after the liner layer deposition; and

moving the substrate from the processing chamber, through a transfer module of the integrated system, into a processing module for performing copper seed layer deposition, the processing module for performing copper seed layer deposition being part of the integrated system, and within the processing module for performing copper seed layer deposition, performing, copper seed layer deposition over the surface of the substrate,

wherein the integrated system enables controlled-ambient transitions within the integrated system to limit exposure of the substrate to uncontrolled ambient conditions outside of the integrated system.

20. The method of claim 19, wherein the surface post-treatment is performed over the surface of the substrate to remove contaminants or to activate the surface of the substrate in preparation for the copper seed layer deposition.

21. The method of claim 19, wherein substrate processing on substrate is performed in the sequence of surface pre-treatment, barrier layer deposition, liner layer deposition, and surface post-treatment.

22. The method of claim 19, the metals in the barrier layer and the liner layer are selected from the group consisting of tantalum (Ta), titanium (Ti), tungsten (W), zirconium (Zr), hafnium (Hf), molybdenum (Mo), niobium (Nb), vanadium (V), ruthenium (Ru) and chromium (Cr).