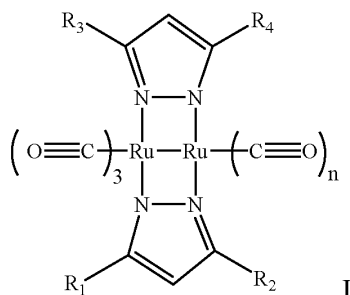


Claims

What is claimed is

1. An ALD or ALD-like precursor comprising ruthenium, represented by Formula I:



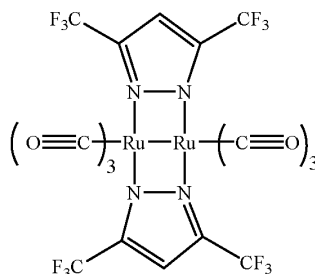
wherein

R_1 , R_2 , R_3 and R_4 are each independently selected from the group of a substituted or unsubstituted C_1 to C_{20} linear or branched or cyclic alkyl and a substituted or unsubstituted C_1 to C_{20} linear or branched or cyclic halogenated alkyl;

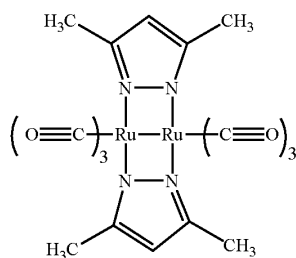
$n = 2$ or 3 ; and

the precursor is preferably substantially free of water, metal ions or metals, and organic impurities.

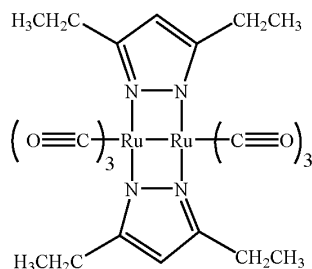
2. The precursor of claim 1, wherein R_1 , R_2 , R_3 and R_4 are each independently one of $-CH_3$, $-CH_2CH_3$, $-CH_2CH_2CH_3$, $-CH(CH_3)_2$, $-CH_2CH(CH_3)_2$, $-C(CH_3)_3$, $-CF_3$, $-CF_2CF_3$, $-CF_2CF_2CF_3$, $-CF(CF_3)_2$, $-C(CF_3)_3$.
3. The precursor of claim 1, wherein at least one of R_1 , R_2 , R_3 and R_4 is a substituted or unsubstituted C_1 to C_8 perfluorinated alkyl.
4. The precursor of claim 1, wherein $n = 2$.
5. The precursor of claim 1, wherein $n = 3$.
6. The precursor of claim 1, wherein each of R_1 , R_2 , R_3 and R_4 is the same group.
7. The precursor of claim 1, wherein each of R_1 and R_4 or R_2 and R_3 are the same group.
8. The precursor of claim 1, having the structure:



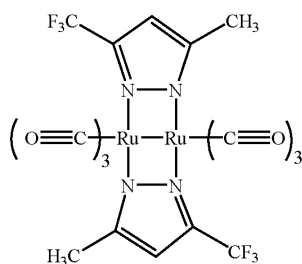
9. The precursor of claim 1, having the structure:



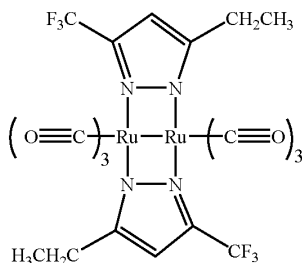
10. The precursor of claim 1, having the structure:



11. The precursor of claim 1, having the structure:



12. The precursor of claim 1, having the structure:



13. An ALD or ALD-like process comprising the step of depositing a ruthenium-containing layer derived from a precursor of any of claims 1 to 12 on a surface of a substrate.

14. The process of claim 13, wherein the surface comprises at least one of Al_2O_3 , ZrO_2 , HfO_2 , SiO_2 , WN, WCN, TiN, Cu, Co, Mo, W and combinations thereof.

15. The process of claim 13, wherein the ALD or ALD-like process is conducted at a temperature below approximately 300 °C.

16. The process of claim 13, wherein the ALD or ALD-like process is conducted at a temperature below approximately 275 °C.

17. The process of claim 13, wherein the ALD or ALD-like process is conducted at a temperature below approximately 250 °C.
18. The process of claim 13, wherein the ALD or ALD-like process is conducted at a temperature in the range of approximately 200 °C and approximately 300 °C.
19. The process of claim 13, wherein the ALD or ALD-like process is conducted at a temperature in the range of approximately 235 °C and approximately 300 °C.
20. The process of claim 13, further comprising the use of a co-reactant.
21. The process of claim 13, further comprising the use of an oxygen-free co-reactant.
22. The process of claim 13, further comprising the use of an oxygen-containing co-reactant.
23. The process of claim 13, further comprising the use of H₂ as a co-reactant.
24. The process of claim 13, further comprising the use of O₂ as a co-reactant.
25. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure between approximately 0.01 and approximately 20 Torr.
26. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure between approximately 1 and approximately 15 Torr.
27. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure between approximately 5 and approximately 15 Torr.
28. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure between approximately 5 and approximately 10 Torr.
29. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure of approximately 5 Torr.
30. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure of approximately 10 Torr.
31. The process of claim 13, wherein the ALD or ALD-like process is conducted at a pressure of approximately 15 Torr.
32. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor pulse time of approximately 1 sec to approximately 15 sec.
33. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor pulse time of approximately 5 sec to approximately 10 sec.
34. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor pulse time of approximately 10 sec.
35. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor pulse time of approximately 15 sec.
36. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor purge time of approximately 1 sec to approximately 20 sec.

37. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor purge time of approximately 5 sec to approximately 15 sec.
38. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor purge time of approximately 10 sec. to approximately 15 sec.
39. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor purge time of approximately 10 sec.
40. The process of claim 13, wherein the ALD or ALD-like process is conducted with a precursor purge time of approximately 15 sec.
41. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 1 sec to approximately 60 sec.
42. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 10 sec to approximately 50 sec.
43. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 20 sec to approximately 40 sec.
44. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 30 sec to approximately 40 sec.
45. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 30 sec.
46. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 40 sec.
47. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 50 sec.
48. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 1 sec to approximately 90 sec.
49. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 10 sec to approximately 80 sec.
50. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 20 sec to approximately 70 sec.
51. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 30 sec to approximately 60 sec.
52. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 50 sec.
53. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 60 sec.

54. The process of claim 13, wherein the ALD or ALD-like process is conducted with a co-reactant purge time of approximately 70 sec.
55. An ALD or ALD-like-deposited film comprising the reaction product of a precursor of any of claims 1 to 12 and at least one oxygen-free co-reactant.
56. The ALD- or ALD-like deposited film of claim 55, wherein the oxygen-free co-reactant comprises hydrogen.
57. The ALD- or ALD-like deposited film of claim 55, wherein the oxygen-free co-reactant comprises a nitrogen-containing co-reactant.
58. The ALD- or ALD-like deposited film of claim 55, wherein the oxygen-free co-reactant comprises one or more of ammonia, hydrazine, an alkylhydrazine and an alkyl amine.
59. An ALD- or ALD-like deposited film comprising the reaction product of a precursor of any of claims 1 to 12 and at least one oxygen-containing co-reactant.
60. The ALD- or ALD-like deposited film of claim 59, wherein the oxygen-containing co-reactant comprises one or more of oxygen, hydrogen peroxide and nitrous oxide.
61. The ALD- or ALD-like deposited film of claim 59, wherein the oxygen-containing co-reactant comprises one or more of ozone, elemental oxygen and molecular oxygen/O₂.
62. The ALD- or ALD-like deposited film of claim 59, wherein the oxygen-containing co-reactant comprises O₂.
63. The process of claim 13, wherein the ALD or ALD-like process is conducted:
- (i) at a temperature of approximately 245 °C;
 - (ii) at a pressure of approximately 10 Torr;
 - (iii) with a precursor pulse time of approximately 10 sec;
 - (iv) with a precursor purge time of approximately 15 sec;
 - (v) with a co-reactant pulse time of approximately 40 sec; and
 - (vi) with a co-reactant purge time of approximately 60 sec.
64. The process of claim 63, wherein the co-reactant is H₂.
65. The use of the precursor of any one of claims 1 to 12 in ALD and ALD-like processes.