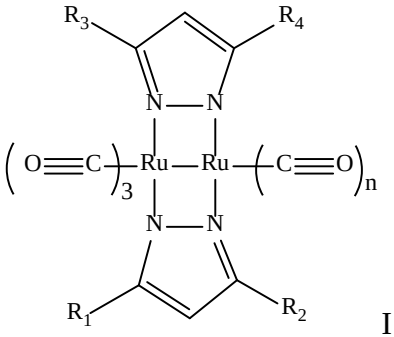
Claims

What is claimed is

1. An ALD or ALD-like process depositing a ruthenium-containing layer on a substrate comprising:

(i) exposing a surface of the substrate to a precursor comprising one or more ruthenium compound of Formula I:



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 alkyl and a substituted or unsubstituted C_1 to C_{20} linear or branched halogenated alkyl;

n = 2 or 3; and

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

(ii) thereafter exposing the surface of the substrate to one or more co-reactant;

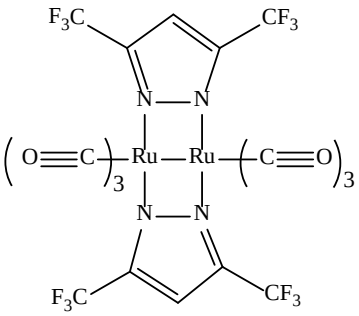
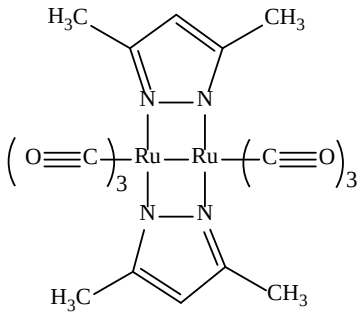
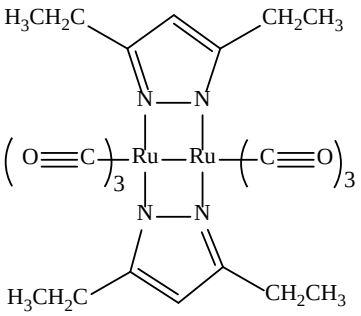
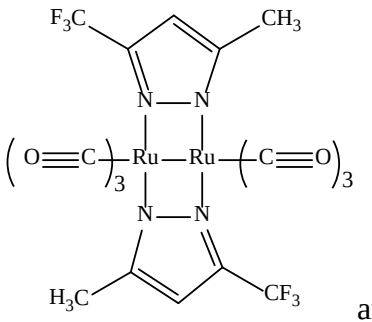
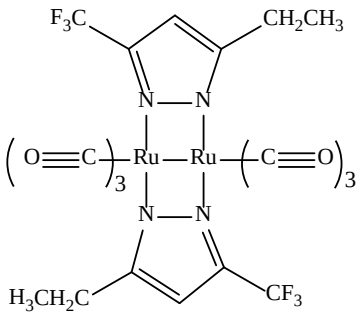
wherein

the process is conducted at a temperature in the range of approximately 200 °C and below approximately 300 °C, and

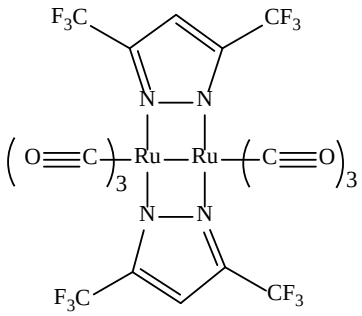
the ruthenium-containing layer has an as-deposited resistivity of below about 40 μOhm·cm.

2. The process of claim 1, wherein R_1, R_2, R_3 and R_4 in Formula Iare each independently one of $-CH_3$, $-CH_2CH_3$, $-CH_2CH_2CH_3$, $-CH(CH3)_2$, $-CH_2CH(CH_3)_2$, $-C(CH_3)_3$, $-CF_3$, $-CF_2CF_3$, $-CF_2CF_2CF_3$, $-CF(CF_3)_2$, $-C(CF_3)_3$.

3. The process of claim 1, wherein the precursor comprises one or more compound of Formula I selected from the group of:





and


4. The process of claim 1, wherein the precursor comprises a compound of Formula I having the structure:



5. The process of claim 1, 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.

6. The process of claim 1, wherein the ALD or ALD-like process is conducted at a temperature below approximately 275 °C.

7. The process of claim 1, wherein the ALD or ALD-like process is conducted at a temperature below approximately 250 °C.

8. The process of claim 1, wherein the ALD or ALD-like process is conducted at a temperature in the range of approximately 225 °C and approximately 295 °C.

9. The process of claim 1, wherein the ALD or ALD-like process is conducted at a temperature in the range of approximately 235 °C and approximately 300 °C.

10. The process of claim 1, wherein the one or more co-reactant comprises an oxygen-free co-reactant.

11. The process of claim 1, wherein the one or more co-reactant comprises an oxygen-containing co-reactant.

12. The process of claim 1, wherein the one or more co-reactant comprises H_2.

13. The process of claim 1, wherein the one or more co-reactant comprises one or more ozone, elemental oxygen and molecular oxygen/O_2 hydrogen peroxide and nitrious oxide.

14. The process of claim 1, wherein the ALD or ALD-like process is conducted at a pressure between approximately 1 and approximately 15 Torr.

15. The process of claim 1, wherein the ALD or ALD-like process is conducted with a precursor pulse time of approximately 1 sec to approximately 15 sec.

16. The process of claim 1, wherein the ALD or ALD-like process is conducted with a co-reactant pulse time of approximately 1 sec to approximately 60 sec.

17. A ruthenium-containing layer deposited by the process of claim 1, wherein the layer comprises the reaction product of a precursor of claim 1 and at least one oxygen-free co-reactant.

18. The ruthenium-containing layer of claim 17, wherein the at least one oxygen-free co-reactant comprises hydrogen.

19. The ruthenium-containing layer of claim 17, wherein the at least one oxygen-free co-reactant comprises a nitrogen-containing co-reactant.

20. The ruthenium-containing layer of claim 17, wherein the at least one oxygen-free co-reactant comprises one or more of ammonia, hydrazine, an alkylhydrazine and an alkyl amine.

21. A ruthenium-containing layer deposited by the process of claim 1, wherein the layer comprises the reaction product of the precursor and at least one oxygen-containing co-reactant.

22. The ruthenium-containing layer of claim 21, wherein the at least one oxygen-containing co-reactant comprises one or more of oxygen, hydrogen peroxide and nitrous oxide.

23. The ruthenium-containing layer of claim 21, wherein the at least one oxygen-containing co-reactant comprises one or more of ozone, elemental oxygen and molecular oxygen/O_2.

24. The ruthenium-containing layer of claim 21, wherein the at least one oxygen-containing co-reactant comprises O_2.