Transactions (2003), (23), 4457-4465).

Today, there is a need for providing liquid or low melting point (<50°C. at standard pressure), highly thermally stable, Niobium and Vanadium containing precursor molecules suitable for vapor phase film deposition with controlled thickness and composition at high temperature.

SUMMARY

In one aspect, the present disclosure provides a metal-containing film forming composition comprising a precursor having the formula:

$$M(=NR^1)(OR^2)(OR^3)_mL$$

wherein, M = Nb; R^1-R^3 = independently H or C1-C10 alkyl group;

L = Substituted or unsubstituted cyclopentadienes, cyclohexadienes, cycloheptadienes, cyclooctadienes, fluorenes, indenes, fused ring systems, propene, butadiene, pentadienes, hexadienes, heptadienes; m = 1.

In another aspect, there is provided a method of forming a Metal-containing film, the method comprising introducing into a reactor having a substrate therein a vapor of the metal-containing film forming composition described herein; and depositing at least part of the precursor onto the substrate.

DETAILED DESCRIPTION

According to the invention, certain precursors have been found suitable for the deposition of Nb and V containing thin films by ALD processes and to have the following advantages:

- They are liquid at room temperature or having a melting point lower than 50°C,
- They are thermally stable to enable proper distribution (gas phase or direct liquid injection) without particles generation,
- They are thermally stable to allow wide self-limited ALD window, allowing deposition of a variety of Nb and V containing films, by using one or a combination of co-reactants. The co-reactant can typically be selected from an oxidizing agent, such as O2, O3, H2O, H2O2, alcohols, or a nitriding agent such as ammonia, amines, polyamines, hydrazines, NO. Such co-reactant may be

plasma activated or not

They can also be used in combination with another precursor to deposit mixed films. More particularly, these precursors are suitable to be used with precursors of group IV and other group V elements, as well as with phosphorous or lithium compounds for energy storage applications for instance.

According to a first embodiment, the invention relates to a Metal-containing film forming composition comprising a precursor having the formula:

$$M(=NR^1)(OR^2)(OR^3)_mL$$

Wherein, M = V or Nb or Ta; R^1-R^3 = independently H or C1-C10 alkyl group;
L = Substituted or unsubstituted cyclopentadienes, cyclohexadienes, cycloheptadienes, cyclooctadienes, fluorenes, indenes, fused ring systems, propene, butadiene, pentadienes, hexadienes, heptadienes; m = 0 or 1.

CLAIMS

1. A Metal-containing film forming composition comprising a precursor having the formula:

$$M(=NR^1)(OR^2)(OR^3)_mL$$

Wherein, M = Nb; R^1-R^3 = independently H or C1-C10 alkyl group;
L = Substituted or unsubstituted cyclopentadienes, cyclohexadienes, cycloheptadienes, cyclooctadienes, fluorenes, indenes, fused ring systems, propene, butadiene, pentadienes, hexadienes, heptadienes; m = 1.

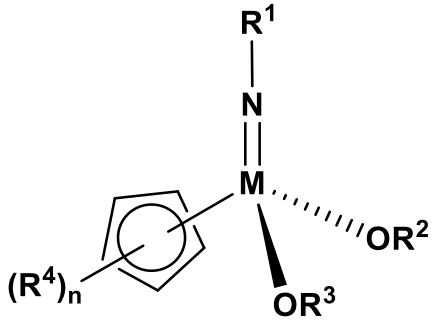
2. The Metal-containing film forming composition of claim 1, wherein R^1 is H, R^2 is tBu; R^3 is Et.

3. The Metal-containing film forming composition of claim 1, wherein R^1 is H, R^2 and R^3 are tBu.

4. The Metal-containing film forming composition of claim 1, wherein R^1 is H, R^2 is tBu; R^3 is sBu.

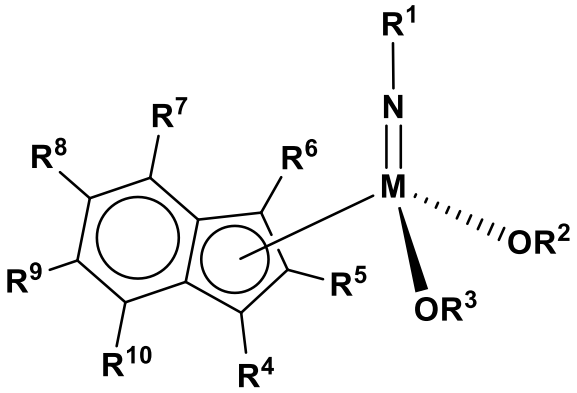
5. The Metal-containing film forming composition of claim 1, 2, 3 or 4 wherein, M is Niobium.

6. The Metal-containing film forming composition according to any one of claims 1 to 5, of formula:



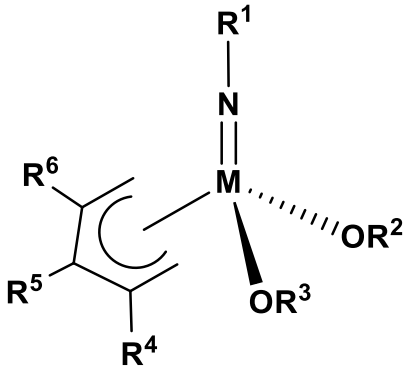
wherein each R^4 is H or a C1-C10 alkyl group or a fluoro group; $n \leqq 5$.

7. The Metal-containing film forming composition according to any one of claims 1 to 5, of formula:



wherein each R^4 to R^{10} is independently H or a C1-C10 alkyl group or a fluoro group.

8. The Metal-containing film forming composition according to any one of claims 1 to 5, of formula:



wherein each R^4 to R^6 is independently H or a C1-C10 alkyl group, or a fluoro group.

9. A method of forming a Metal-containing film, the method comprising introducing into a reactor having a substrate therein a vapor of the Metal-containing film forming composition of anyone of claims 1 to 8; and depositing at least part of the precursor onto the substrate.

10. The method of claim 9, further comprising introducing a reactant into the reactor.

11. The method of claim 10, wherein the reactant is selected from the group consisting of O_2, O_3, H_2O, H_2O_2, NO, N_2O, NO_2, TMPO, oxygen radicals thereof, and mixtures thereof.

12. The method of claim 10, wherein M is Nb and the Niobium-containing film forming composition and the reactant are introduced into the chamber sequentially and the reactor is configured for atomic layer deposition.

13. The method of claim 9 where the substrate is a cathode active material powder.

14. The method of claim 9 where the substrate is a cathode material consisting of a cathode active material powder, a conductive carbon and a binder material deposited onto a current collector foil.