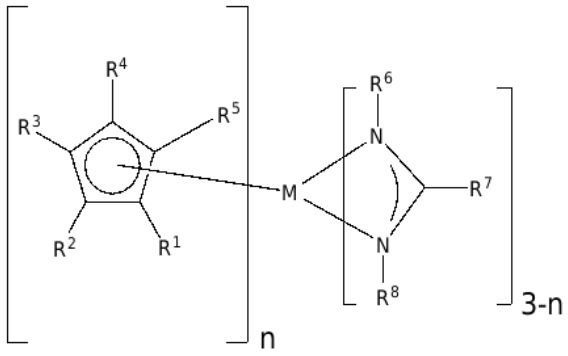
CLAIMS

What is claimed is:

1. A transition metal precursor comprising a cyclopentadienyl ligand and an amidinate ligand of Formula I:



Formula I

wherein

(i) M is one of La, Sc, Y, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu;

(ii) in the cyclopentadienyl ligand R^1, R^2, R^3, R^4 and R^5 are each a substituent independently selected from H, an unsubstituted linear C_1-C_6 alkyl group, a linear C_1-C_6 alkyl group substituted with a halogen, a linear C_1-C_6 alkyl group substituted with an amino group, an unsubstituted branched C_3-C_6 alkyl group and a branched C_3-C_6 alkyl group substituted with a halogen, a branched C_3-C_6 alkyl group substituted with an amino group, and $-Si(CH_3)_3$, wherein (a) R^1, R^2, R^3, R^4 and R^5 comprise at least three different substituents and (b) at least two of R^1, R^2, R^3, R^4 and R^5 are H;

(iii) in the amidinate ligand R^6, R^7 and R^8 are each a substituent independently selected from H, an unsubstituted linear C_1-C_6 alkyl group, a linear C_1-C_6 alkyl group substituted with a halogen, a linear C_1-C_6 alkyl group substituted with an amino group, an unsubstituted branched C_3-C_6 alkyl group and a branched C_3-C_6 alkyl group substituted with a halogen, a branched C_3-C_6 alkyl group substituted with an amino group, and $-Si(CH_3)_3$;

(iv) n = 1 or 2; and

(v) the precursor is liquid below about 80 °C.

2. The precursor of claim 1, wherein M is one of La, Ce, Y and Sm.

3. The precursor of claim 1, wherein M is La.

4. The precursor of claim 1, wherein M is Ce.

5. The precursor of claim 1, wherein M is Y.

6. The precursor of claim 1, wherein each cyclopentadienyl ligand is derived independently from the cyclopentadiene shown in Table 1:

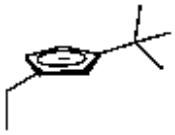
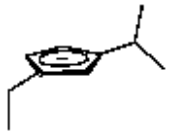
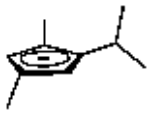
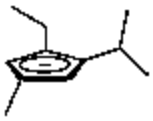
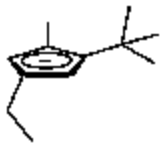
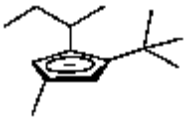
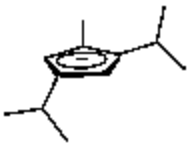
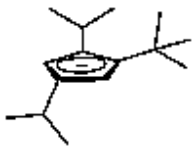
Cp Structure	Cp Structure	Cp Structure
 **1A**	 **1B**	 **1C**
 **1D**	 **1E**	 **1F**
 **1G**	 **1H**	 **1I**
 **1J**	 **1K**	 **1L**
 **1M**	 **1N**	 **1O**
 **1P**	 **1Q**	 **1R**
 **1S**	 **1T**	 **1U**

Table 1.

7. The precursor of 1, wherein the amidinate ligand is selected from the amidinate ligands shown in Table 2:

Amidinate Structure	Amidinate Structure	Amidinate Structure

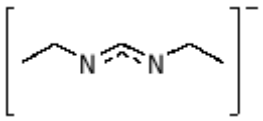
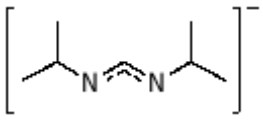
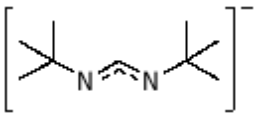
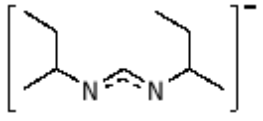
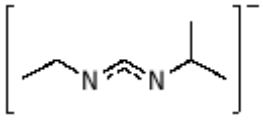
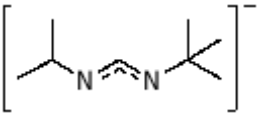
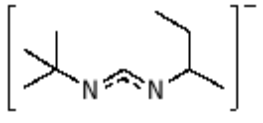
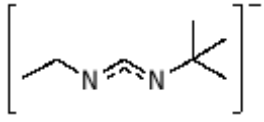
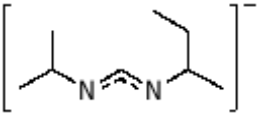
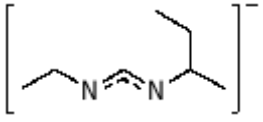
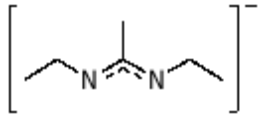
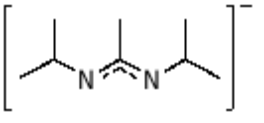
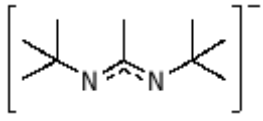
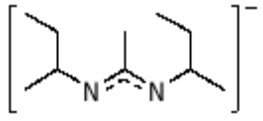
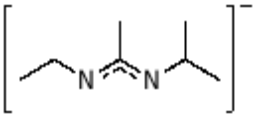
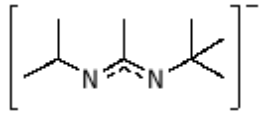
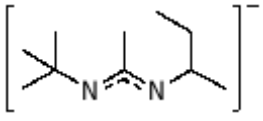
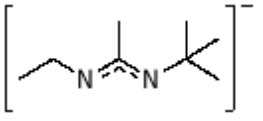
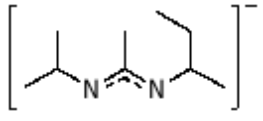
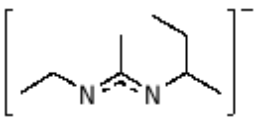
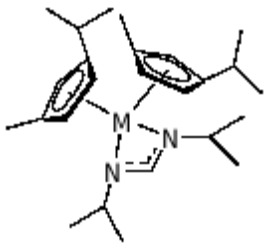
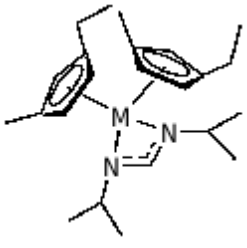
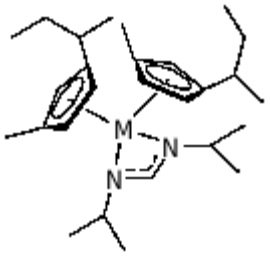
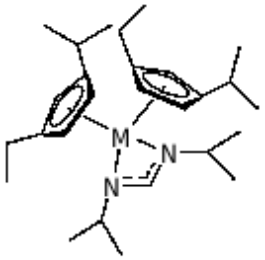
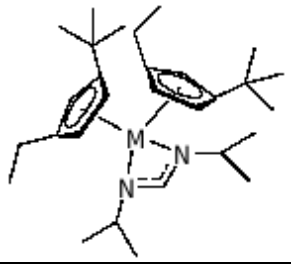
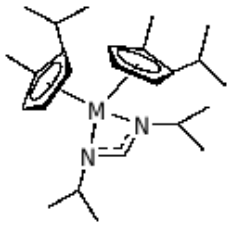
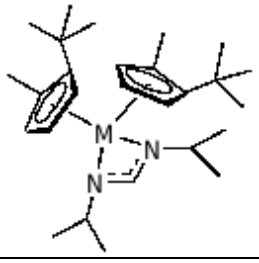
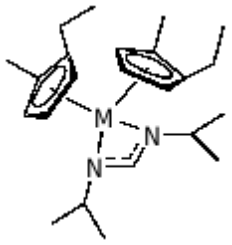
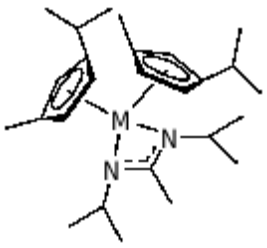
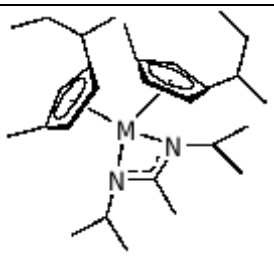
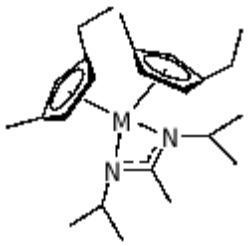
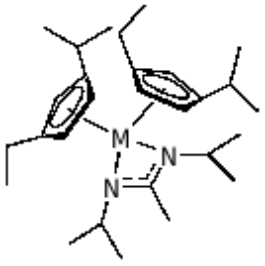
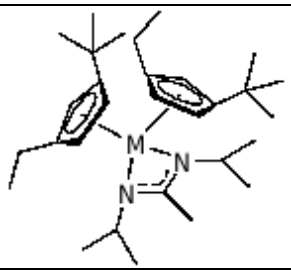
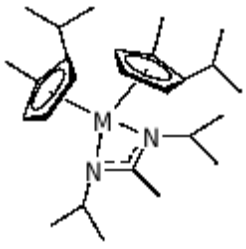
 **2A**	 **2B**	 **2C**
 **2D**	 **2E**	 **2F**
 **2G**	 **2H**	 **2I**
 **2J**	 **2K**	 **2L**
 **2M**	 **2N**	 **2O**
 **2P**	 **2Q**	 **2R**
 **2S**	 **2T**	

Table 2.

8. The precursor of claim 1, wherein the precursor has a structure as shown in Table 3:

Formula	Compound	Formula	Compound
$(1A)_2$-M-(2B)		$(1C)_2$-M-(2B)	

$(1D)_2$-M-(2B)		$(1F)_2$-M-(2B)	
$(1E)_2$-M-(2B)		$(1H)_2$-M-(2B)	
$(1I)_2$-M-(2B)		$(1J)_2$-M-(2B)	
$(1A)_2$-M-(2L)		$(1D)_2$-M-(2L)	
$(1C)_2$-M-(2L)		$(1F)_2$-M-(2L)	
$(1E)_2$-M-(2L)		$(1H)_2$-M-(2L)	

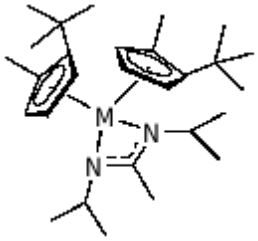
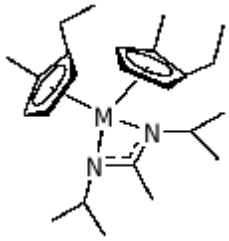
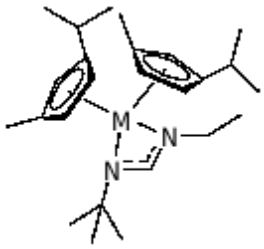
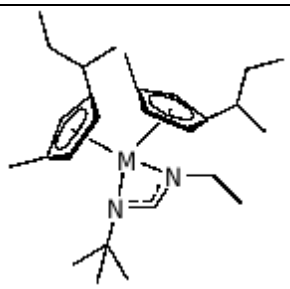
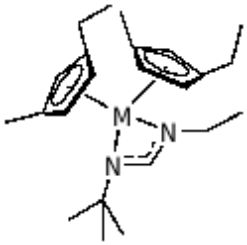
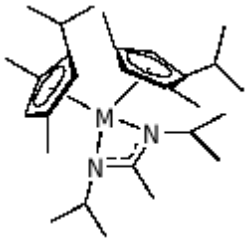
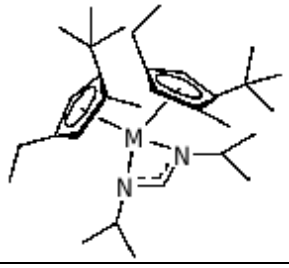
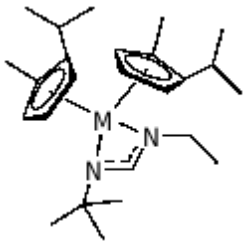
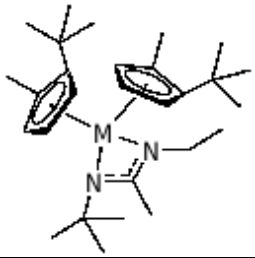
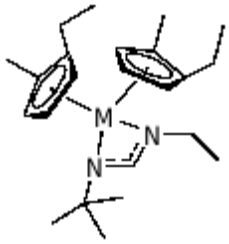
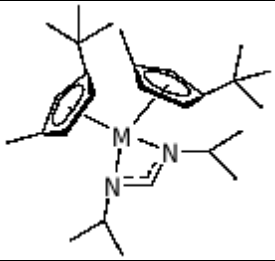
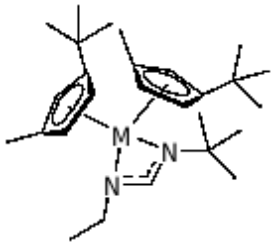
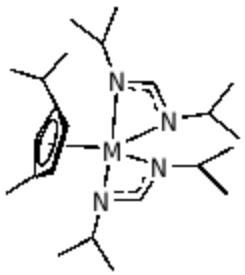
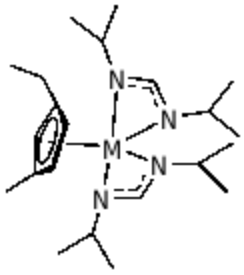
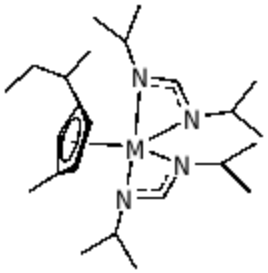
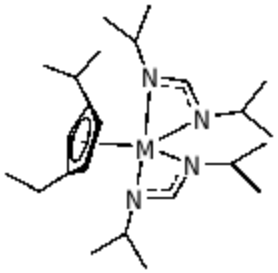
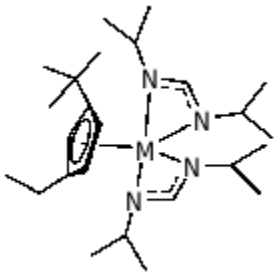
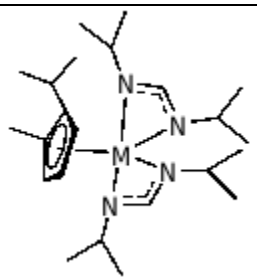
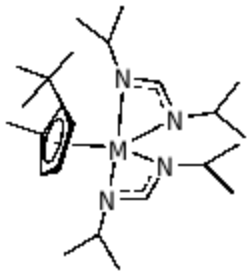
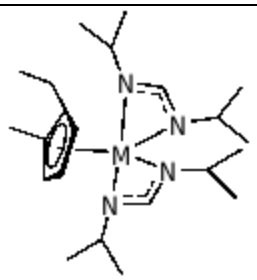
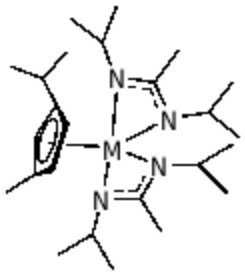
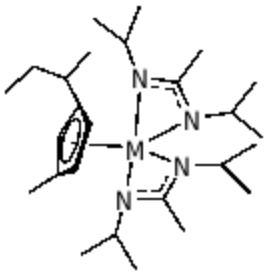
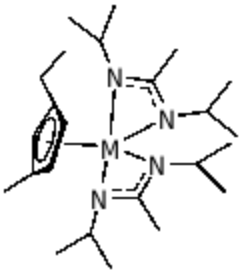
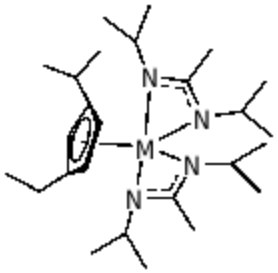
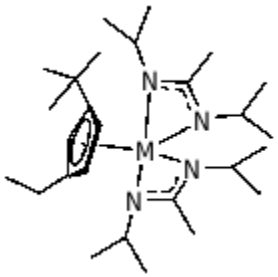
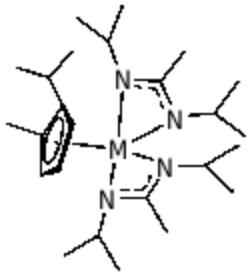
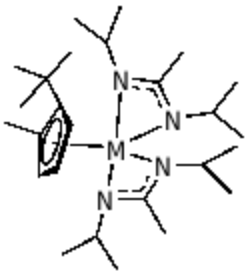
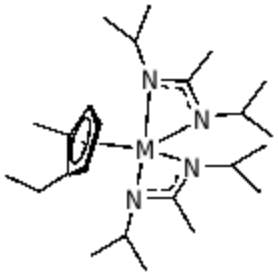
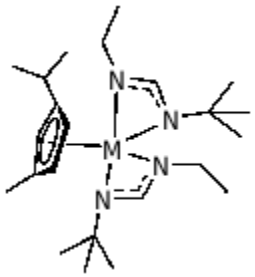
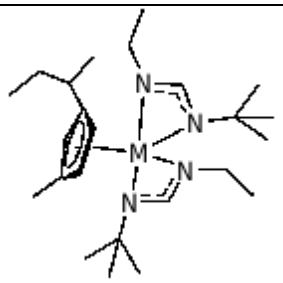
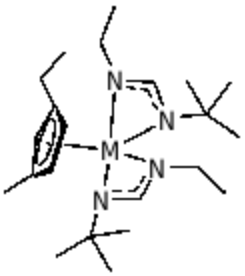
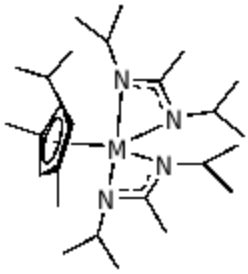
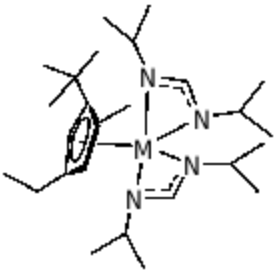
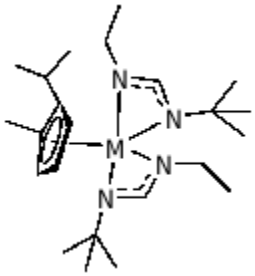
$(1I)_2$-M-(2L)		$(1J)_2$-M-(2L)	
$(1A)_2$-M-(2H)		$(1D)_2$-M-(2H)	
$(1C)_2$-M-(2H)		$(1O)_2$-M-(2L)	
$(1Q)_2$-M-(2B)		$(1H)_2$-M-(2H)	
$(1I)_2$-M-(2R)		$(1J)_2$-M-(2H)	
$(1B)_2$-M-(2B)		$(1B)_2$-M-(2H)	

Table 3.

9. The precursor of claim 1, wherein the precursor has a structure as shown in Table 4:

Formula	Compound	Formula	Compound
(1A)-M-(2B)$_2$		(1C)-M-(2B)$_2$	
(1D)-M-(2B)$_2$		(1F)-M-(2B)$_2$	
(1E)-M-(2B)$_2$		(1H)-M-(2B)$_2$	
(1I)-M-(2B)$_2$		(1J)-M-(2B)$_2$	
(1A)-M-(2L)$_2$		(1D)-M-(2L)$_2$	

(1C)-M-(2L)$_2$		(1F)-M-(2L)$_2$	
(1E)-M-(2L)$_2$		(1H)-M-(2L)$_2$	
(1I)-M-(2L)$_2$		(1J)-M-(2L)$_2$	
(1A)-M-(2H)$_2$		(1D)-M-(2H)$_2$	
(1C)-M-(2H)$_2$		(1O)-M-(2L)$_2$	
(1Q)-M-(2B)$_2$		(1H)-M-(2H)$_2$	

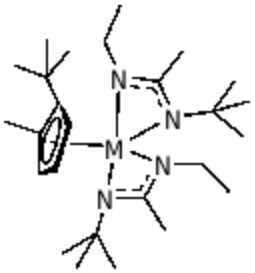
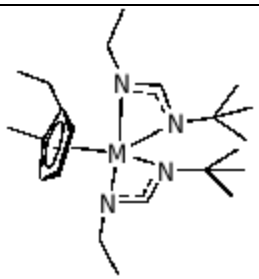
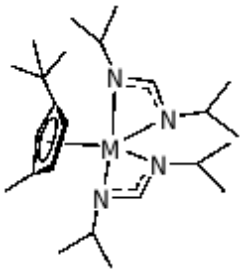
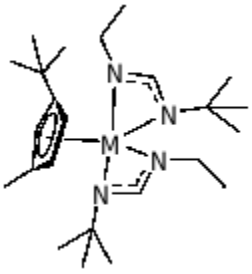
(1I)-M-$(2R)_2$		(1J)-M-$(2H)_2$	
(1B)-M-$(2B)_2$		(1B)-M-$(2H)_2$	

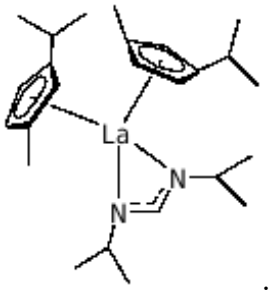
Table 4.

10. The precursor of claim 1, wherein R^1, R^2, R^3, R^4, R^5, R^6, R^7 and R^8 are each independently selected from H, an unsubstituted linear C_1-C_5 linear alkyl group and an unsubstituted branched C_3-C_6 alkyl group.

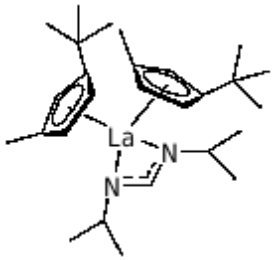
11. The precursor of claim 1, wherein n = 1.

12. The precursor of claim 1, wherein n = 2.

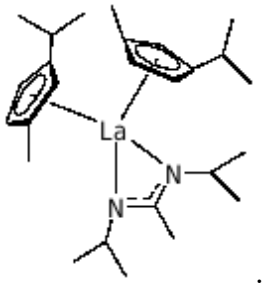
13. The precursor of claim 1 having the following structure:



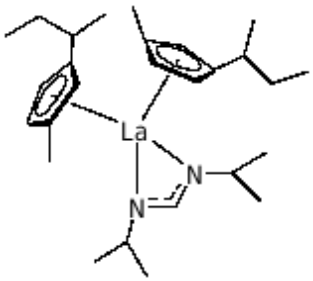
14. The precursor of claim 1 having the following structure:



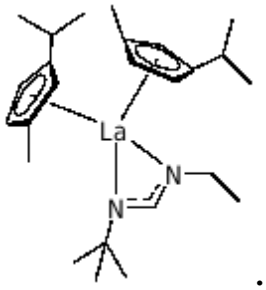
15. The precursor of claim 1 having the following structure:



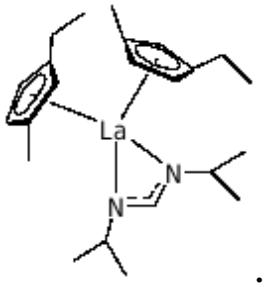
16. The precursor of claim 1 having the following structure:



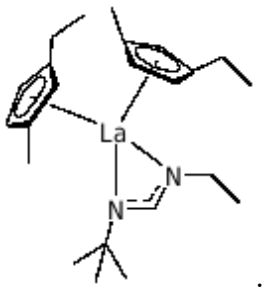
17. The precursor of claim 1 having the following structure:



18. The precursor of claim 1 having the following structure:



19. The precursor of claim 1 having the following structure:



20. A method for forming a transition metal-containing film on at least one surface of a substrate comprising:

a. providing the at least one surface of the substrate in a reaction vessel;

b. forming a transition metal-containing film on the at least one surface by a deposition process chosen from a chemical vapor deposition (CVD) process and an atomic layer deposition (ALD) process using the precursor of any of claims 1-19 as a metal source compound for the deposition process.

21. A mixture comprising one or more precursor of any of claims 1-19 and a solvent selected from the group of toluene, mesitylene, isopropylbenzene, 4-isopropyl toluene, 1,3-diisopropylbenzene, octane, dodecane, 1,2,4-trimethylcyclohexane, n-butylcyclohexane, and decahydronaphthalene and combinations thereof.