

## CLAIMS

1. A cathode or a cathode active material comprising at least a partial surface coating of a doped metal oxide film, preferably the metal is selected from Niobium,  
5 Tantalum, Vanadium, Zirconium, Titanium, Hafnium, Tungsten, Molybdenum, Chromium and combinations thereof.
2. The cathode or a cathode active material of claim 1, wherein the doped metal oxide film is either a metal, oxygen and carbon-containing film or a metal, oxygen and  
10 phosphorus containing film.
3. The cathode or a cathode active material of claim 1, wherein the doped metal oxide film is a doped Niobium oxide film.
- 15 4. The cathode or a cathode active material of claim 1, wherein the doped metal oxide film is a Niobium, oxygen and carbon-containing film or a Niobium, oxygen and phosphorus containing film.
5. The cathode or a cathode active material of any of claims 1-4, wherein the  
20 cathode or a cathode active material is only partially coated with the doped metal oxide film.
6. The cathode or a cathode active material of claim any of claims 1-5, wherein the doped metal oxide film has an average thickness of 0.02 nm to 10nm, preferably 0.1  
25 nm to 5nm, most preferably 0.2 to 2 nm.
7. The cathode or a cathode active material of any of claims 1-4, wherein the doped metal oxide film has an atomic percentage for carbon atoms from 5% to 50%, preferably 10% to 30%, most preferably 15 to 25%.  
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8. The cathode or a cathode active material of claim any of claims 3-7, wherein the doped metal oxide film has a refractive index of 1.5 to 2.5, preferably 1.6 to 2.1, most preferably 1.7 to 2.0.

9. The cathode or a cathode active material of claim 1, wherein the doped metal oxide has an average atomic composition of  $M_xO_yD_z$ , wherein M is a transition metal or a II-A to VI-B element, O is oxygen, and D is a dopant atom other than lithium, M or O, preferably D is selected from C, Si, Sn, B, Al, N, P, or S, and wherein x = 10 to 60%, y ranges from 10 to 60%, and z ranges from 5 to 50%, preferably from 10 to 30%.

10. The cathode or a cathode active material of claim 9, wherein the cathode or a cathode active material is only partially coated with the doped metal oxide film.

11. The cathode or a cathode active material of claim 9 or 10, wherein the doped metal oxide film has an average thickness of 0.02 nm to 10 nm, preferably 0.1 nm to 5 nm, most preferably 0.2 to 2 nm.

12. The cathode or a cathode active material of any of claims 9-11, wherein the doped metal oxide film has an atomic percentage for carbon atoms from 5% to 50%, preferably 10% to 30%, most preferably 15 to 25%.

13. The cathode or a cathode active material of claim any of claims 9-12, wherein the doped metal oxide film has a refractive index of 1.5 to 2.5, preferably 1.6 to 2.1, most preferably 1.7 to 2.0.

14. A proton exchange membrane battery comprising a cathode or cathode active material according to any of claims 1-13.

15. A method of coating a cathode or a cathode active material with a doped metal oxide film, the method comprising the steps of:

a1. exposing the cathode or cathode active material to a chemical precursor vapor, and

b1. depositing the doped metal oxide film on the cathode or cathode active material.

16. The method of claim 15, further comprising a step a2. of exposing the cathode or cathode active material to a co-reactant.

17. The method of claim 16, wherein the step a1. of exposing the cathode or cathode active material to a chemical precursor vapor and the step a2. of exposing the cathode or cathode active material to a co-reactant, are sequentially performed.

5 18. The method of claim 17, further comprising a step a1i. of purging the chemical precursor vapor prior to step a2. of exposing the cathode or cathode active material to a co-reactant.

10 19. The method of claim 18, wherein the step b1. depositing the doped metal oxide film on the cathode or cathode active material comprises an atomic layer deposition step.

15 20. The method of claim 18, wherein the step b1. of depositing the doped metal oxide film on the cathode or cathode active material comprises a chemical vapor deposition step.

20 21. The method of claims 15-20, wherein the co-reactant is an oxygen source such as O<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>O, H<sub>2</sub>O<sub>2</sub>, NO, NO<sub>2</sub>, N<sub>2</sub>O or a NO<sub>x</sub>; an oxygen-containing silicon precursor, an oxygen-containing tin precursor, a phosphate such as trimethylphosphate, diethyl phosphoramidate, or a sulfate.

25 22. The method of any of claims 15-19, wherein the doped metal oxide film produced by step b1. has an average atomic composition of M<sub>x</sub>O<sub>y</sub>D<sub>z</sub>, wherein M is a transition metal or a II-A to VI-B element, preferably M is selected from Niobium, Tantalum, Vanadium, Tungsten, Molybdenum, Chromium, Hafnium, Zirconium, Titanium, and combinations thereof, O is oxygen, and D is a dopant atom other than lithium, M or O, preferably D is selected from C, Si, Sn, B, Al, N, P, or S, and wherein x = 0.1-0.3, y = 0.3-0.65 and z = 0.1-0.3.

30 23. The method of any of claims 15-22, wherein one or more of steps are repeated.

24. The method of any of claims 15-23, wherein a temperature of the chemical precursor vapor and/or the cathode or cathode active material is 200 degrees C or less,

preferably 50 degrees C to 200 degrees C, more preferably 100 degrees C to 150 degrees C.

25. The method of any of claims 15-24, wherein the cathode active material, or the  
5 cathode active material in the cathode, is selected from the group consisting of a)  
layered oxides such as Ni-rich cathode materials like NMC (lithium nickel manganese  
cobalt oxide) and NCA (lithium nickel cobalt aluminum oxide); b) spinel cathode  
materials such as LMO (lithium manganese oxide), LNMO (lithium nickel manganese  
oxide); c) Olivine structured cathode materials, in particular the family of Olivine  
10 phosphates such as LCP (lithium cobalt phosphate), LNP (lithium nickel phosphate);  
and combinations thereof.