CLAIMS

1. An anode comprising:

a substrate;

a mixed metal oxide (MMO) layer disposed on the substrate; and

an outer layer disposed on the MMO layer;

wherein:

the substrate comprises a conductive or semi-conductive material;

the MMO layer comprises at least one element selected from the elements of groups 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14; and

the outer layer comprises manganese and oxygen.

2. The anode of claim 1, wherein the MMO layer comprises a first metal oxide comprising Pt, Pd, Rh, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Zr, Nb, Mo, Hf, W, Re, Os, Au, Ta, Ru, Ti, Y, Sr, Sn, La, Ce or Ir.

3. The anode of claim 2, wherein the MMO layer further comprises a second metal oxide comprising Pt, Pd, Rh, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Zr, Nb, Mo, Hf, W, Re, Os, Au, Ta, Ru, Ti, Y, Sr, Sn, La, Ce, or Ir.

4. The anode of claim 1, wherein the MMO layer comprises Ta, Ir, and O.

5. The anode of claim 1, wherein the MMO layer comprises Sn, Ir, and O.

6. The anode of claim 1, wherein the MMO layer comprises Ta, Ru, and O.

7. The anode of claim 1, wherein the MMO layer comprises Sn, Ru, and O.

8. The anode of claim 1, wherein the MMO layer comprises Co, Mn, and O.

9. The anode of any one of claims 1-8, further comprising a dopant selected from Ti, Mo, Ru, W, Sr, Sn, Mn, Ta, Co, and Nb, or a combination thereof.

10. The anode of claim 3, wherein the MMO layer comprises a third metal oxide comprising Pt, Pd, Rh, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Zr, Nb, Mo, Hf, W, Re, Os, Au, Ta, Ru, Ti, Y, Sr, Sn, La, Ce, or Ir.

11. The anode of claim 1, wherein the MMO layer comprises Co, Mo, Sn, and O.

12. The anode of claim 2, wherein the MMO layer comprises the first metal oxide at about 10 mol%, about 20 mol%, about 30 mol%, about 40 mol%, about 50 mol%, or about 60 mol%.

13. The anode of claim 3, wherein the MMO layer comprises the second metal oxide at about 0.5 mol%, about 1.0 mol%, about 1.5 mol%, about 2.0 mol%, about 2.5 mol%, or about 3.0 mol%.

14. The anode of claim 10, wherein the MMO layer comprises the third metal oxide at about 0.001 mol%, about 0.002 mol%, about 0.003 mol%, about 0.004 mol%, about 0.005 mol%, about 0.006 mol%, about 0.007 mol%, or about 0.008 mol%.

15. The anode of any one of claims 2-14, wherein the MMO layer comprises oxygen at about 10 mol%, about 20 mol%, about 30 mol%, about 40 mol%, about 50 mol%, or about 60 mol%.

16. The anode of claim 2, wherein the MMO layer comprises the first metal oxide at about 10 wt%, about 20 wt%, about 30 wt%, about 40 wt%, about 50 wt%, or about 60 wt%.

17. The anode of claim 3, wherein the MMO layer comprises the second metal oxide at about 0.5 wt%, about 1.0 wt%, about 1.5 wt%, about 2.0 wt%, about 2.5 wt%, or about 3.0 wt%.

18. The anode of claim 10, wherein the MMO layer comprises the third metal oxide at about 0.001 wt%, about 0.002 wt%, about 0.003 wt%, about 0.004 wt%, about 0.005 wt%, about 0.006 wt%, about 0.007 wt%, or about 0.008 wt%.

19. The anode of any one of claims 1-18, wherein the MMO layer comprises oxygen at about 10 wt%, about 20 wt%, about 30 wt%, about 40 wt%, about 50 wt%, or about 60 wt%.

20. The anode of any one of claims 1-19, wherein the MMO layer comprises from about 5 atomic % (at. %) Ir to about 65 at. % Ir, 17 at. % Ir to about 65 at. % Ir, or about 15 at. % to about 30 at. % Ir.

21. The anode of any one of claims 1-20, wherein the outer layer has a thickness from about 0.1 μm to about 500 μm.

22. The anode of any one of claims 1-21, wherein the MMO layer has a thickness from about 0.1 μm to about 500 μm.

23. The anode of any one of claims 1-22, wherein the outer layer comprises Mn, Mo, Ta, La, Ce, or Sn, or a combination thereof.

24. The anode of any one of claims 1-23, wherein the outer layer further comprises an outer layer dopant.

25. The anode of any one of claims 1-24, wherein the MMO layer comprises one or more additional MMO layers, wherein the additional MMO layer(s) comprises a metal oxide comprising Ta, Ru, Ti, Y, Sr, Sn, La, Ce or Ir.

26. The anode of any one of claims 1-25, wherein the outer layer has a surface morphology comprising spheres, wherein the spheres have a diameter from 0.01 μm to 10 μm.

27. The anode of any one of claims 1-26, wherein O_2 and H^+ and/or H_3O^+ ions are produced selectively at the anode when a voltage is applied to the anode and the anode is contacted with an aqueous solution comprising chloride.

28. The anode of any one of claims 1-27, wherein the outer layer has a surface having a mean area roughness (Sa) of from about 1 μm to about 10 μm.

29. The anode of any one of claims 1-28, wherein the outer layer has a surface having a mean area roughness (Sa) of from about 0 μm to about 1 μm.

30. An electrochemical cell comprising:

(a) a cathodic chamber comprising:

a cathode;

a cathodic gas outlet;

a first solution inlet; and

an alkaline solution outlet;

wherein the cathode is disposed inside the cathodic chamber and coupled to a power source; and

(b) an anodic chamber comprising:

an anode of any one of claims 1-29;

an anodic gas outlet;

a second solution inlet; and

an acidic solution outlet;

wherein the anode is disposed inside the anodic chamber and coupled to a power source.