Claims

1. A method of removing carbonaceous deposits in a liquid-hydrocarbon fueled solid oxide fuel cell, the method comprising:

providing a solid oxide fuel cell system comprising an anode, a cathode, a solid oxide electrolyte oriented between the anode and cathode, an amplifier cathode disposed proximate the solid oxide electrolyte and the cathode, a fuel cell electric circuit electrically connecting the anode and the cathode, and an amplifier electric circuit electrically connecting the anode and the amplifier cathode;

operating the amplifier electric circuit in an electrolytic mode to electrically power the amplifier cathode, wherein the amplifier cathode generates and supplies O^{2-} or CO_3^{2-} to the anode; and

removing the carbonaceous deposits on the anode by converting the carbonaceous deposits to carbon dioxide gas via reaction with the O^{2-} or CO_3^{2-} and expelling the carbon dioxide gas.

2. The method of claim 1, wherein the amplifier electric circuit further comprises at least one battery that powers the amplifier electric circuit.

3. The method of claim 1, wherein the cathode and the amplifier cathode are different compositions.

4. The method of claim 1, wherein the cathode, the amplifier cathode, or both is selected from the group consisting of at least one perovskite material of the general type ABO_3 or $ABMO_3$ or $A_{1-x}Sr_xFe_{1-y}Co_yO_{3-\delta}$ or $A_{1-x}B_xM_{1-y}Mg_yO_{3-\delta}$, wherein:

A is La, Sn, Nd, Gd, Ba or Dy,

B is a 2^+, 3^+, 4^+ or 5^+ cation;

and preferably wherein the perovskite material is $LaSrFeCoO_{3-\delta}$ (LSCF), or $LaSrMnO_{3-\delta}$ (LSM), or $Sr_2MgMo_{0.8}Nb_{0.2}O_{6-\delta}$.

5. The method of claim 1, wherein the anode comprises metal selected from the group consisting of iron (Fe), copper (Cu), nickel (Ni), cobalt (Co),

molybdenum (Mo), gold (Au), ruthenium (Ru), rhodium (Rh), tungsten (W), chromium (Cr), terbium (Tb), magnesium (Mg), platinum (Pt), palladium (Pd), and combinations thereof.

6. The method of claim 1, wherein the electrolyte is zirconia-based, ceria-based, titania-based, a perovskite oxide, or cationic carbonate-based.

7. The method of claim 1, wherein the solid oxide fuel cell system further comprises a liquid fuel atomizer located to distribute the liquid-hydrocarbon fuel across the anode.

8. A method according to claim 1, comprising:

providing a solid oxide fuel cell system comprising an anode, a cathode, a solid oxide electrolyte oriented between the anode and cathode, an amplifier cathode disposed proximate the solid oxide electrolyte and the cathode, a fuel cell electric circuit electrically connecting the anode and the cathode, and an amplifier electric circuit comprising at least one battery, potentiostat, or galvanostat electrically connecting the anode and the amplifier cathode;

monitoring a power reaction speed of the solid oxide fuel cell system;

operating the amplifier electric circuit in an electrolytic mode to electrically power the amplifier cathode, wherein the amplifier cathode generates and supplies O^{2-} or CO_3^{2-} to the anode;

removing the carbonaceous deposits on the anode by converting the carbonaceous deposits to carbon dioxide gas via reaction with the O^{2-} or CO_3^{2-} and expelling the carbon dioxide gas; and

adjusting the current supplied to the amplifier electric circuit to obtain steady-state operation of the removal of the carbonaceous deposits on the anode.

9. The method of claim 1 or claim 8, wherein the amplifier electric circuit further comprises at least one potentiostat that powers and controls the amplifier electric circuit.

10. The method of claim 1 or claim 8, wherein the amplifier electric circuit further comprises at least one galvanostat that powers and controls the amplifier electric circuit.

11. The method of claim 1 or claim 8, wherein the current supplied to the amplifier electric circuit is substantially constant over time.

12. The method of claim 11, wherein the current supplied to the amplifier electric circuit maintains a voltage above the O_2 reduction potential and below the electrolyte reduction potential.

13. The method of claim 1 or claim 8, wherein the current supplied to the amplifier electrode circuit is pulsed.

14. The method of claim 13, wherein the solid oxide fuel cell system further comprises a control circuit to pulse the current supplied to the amplifier electrode circuit such that current is supplied when the power output of the solid oxide fuel cell system drops below 50% of initial operation without carbonaceous deposits.

15. A solid oxide fuel cell system comprising:

an anode,

a cathode,

a solid oxide electrolyte oriented between the anode and cathode, an amplifier cathode disposed proximate the solid oxide electrolyte and the cathode,

a fuel cell electric circuit electrically connecting the anode and the cathode,

an amplifier electric circuit electrically connecting the anode and the amplifier cathode; and

a liquid fuel atomizer located to distribute the liquid-hydrocarbon fuel across the anode, wherein the amplifier electric circuit operates in an electrolytic mode to electrically power the amplifier cathode which generates and supplies O^{2-} or CO_3^{2-} to the anode to remove carbonaceous deposits on the anode by converting the

carbonaceous deposits to carbon dioxide gas via reaction with the O^{2-} or CO_3^{2-} to produce carbon dioxide gas.