SUMMARY

In an aspect, the present disclosure is directed to power systems that generates at least one of electrical energy and thermal energy comprising:

at least one vessel capable of a maintaining a pressure below atmospheric;

reactants capable of undergoing a reaction that produces enough energy to form a plasma in the vessel comprising:

a) a mixture of hydrogen gas and oxygen gas, and/or

water vapor, and/or

a mixture of hydrogen gas and water vapor;

b) a molten metal;

a mass flow controller to control the flow rate of at least one reactant into the vessel;

a vacuum pump to maintain the pressure in the vessel below atmospheric pressure when one or more reactants are flowing into the vessel;

a molten metal injector system comprising at least one reservoir that contains some of the molten metal, a molten metal pump system (*e.g.*, one or more electromagnetic pumps) configured to deliver the molten metal in the reservoir and through an injector tube to provide a molten metal stream, and at least one non-injector molten metal reservoir for receiving the molten metal stream;

at least one ignition system comprising a source of electrical power or ignition current to supply electrical power to the at least one stream of molten metal to ignite the reaction when the hydrogen gas and/or oxygen gas and/or water vapor are flowing into the vessel;

a reactant supply system to replenish reactants that are consumed in the reaction;

a power converter or output system to convert a portion of the energy produced from the reaction (*e.g.*, light and/or thermal output from the plasma) to electrical power and/or thermal power, and a light transparent photovoltaic (PV) window to transmit light from the inside of the vessel to the photovoltaic converter, wherein the PV window spins or a spinning rotating baffle is positioned in front of the window, wherein the rotation speed creates sufficient centrifugal force to remove particles deposited from the reaction.

The power system may comprise a blackbody radiator and a window to output light from the blackbody radiator. Such embodiments may be used to generate light (*e.g.*, used for lighting).

In some examples, the power system may further comprise a gas mixer for mixing the hydrogen and oxygen gases and a hydrogen and oxygen recombiner and/or a hydrogen dissociator. For example, the power system may comprise a hydrogen and oxygen

CLAIMS

What Is Claimed Is:

1. A power system that generates at least one of electrical energy and thermal energy comprising:

at least one vessel capable of a maintaining a pressure below atmospheric;

reactants capable of undergoing a reaction that produces enough energy to form a plasma in the vessel comprising:

a) a mixture of hydrogen gas and oxygen gas, and/or

water vapor, and/or

a mixture of hydrogen gas and water vapor;

b) a molten metal;

a mass flow controller to control the flow rate of at least one reactant into the vessel;

a vacuum pump to maintain the pressure in the vessel below atmospheric pressure when one or more reactants are flowing into the vessel;

a molten metal injector system comprising at least one reservoir that contains some of the molten metal, a molten metal pump system (*e.g.*, one or more electromagnetic pumps) configured to deliver the molten metal in the reservoir and through an injector tube to provide a molten metal stream, and at least one non-injector molten metal reservoir for receiving the molten metal stream;

at least one ignition system comprising a source of electrical power or ignition current to supply electrical power to the at least one stream of molten metal to ignite the reaction when the hydrogen gas and/or oxygen gas and/or water vapor are flowing into the vessel;

a reactant supply system to replenish reactants that are consumed in the reaction;

a power converter or output system to convert a portion of the energy produced from the reaction (*e.g.*, light and/or thermal output from the plasma) to electrical power and/or thermal power, and

a light transparent photovoltaic (PV) window to transmit light from the inside of the vessel to the photovoltaic converter, wherein the PV window spins or a spinning rotating baffle is positioned in front of the window, wherein the rotation speed creates sufficient centrifugal force to remove particles deposited from the reaction.

2. The power system of Claim 1 further comprising a gas mixer for mixing the hydrogen and oxygen gases and a hydrogen and oxygen recombiner and/or a hydrogen dissociator.

3. The power system of Claim 1 wherein the hydrogen and oxygen recombiner comprises a recombiner catalytic metal supported by an inert support material.

4. The power system of Claim 1 wherein an inert gas (*e.g.*, argon) is injected into the vessel.

5. The power system of Claim 1 further comprising a water micro-injector configured to inject water into the vessel (*e.g.*, resulting in a plasma comprising water vapor).

6. The power system of Claim 1 wherein molten metal injection system further comprises electrodes in the molten metal reservoir and the non-injection molten metal reservoir; and the ignition system comprises a source of electrical power or ignition current to supply opposite voltages to the injector and non-injector reservoir electrodes; wherein the source of electrical power supplies current and power flow through the stream of molten metal to cause the reaction of the reactants to form a plasma inside of the vessel.

7. The power system of Claim 1 wherein the molten metal pump system is one or more electromagnetic pumps and each electromagnetic pump comprises one of a

a) DC or AC conduction type comprising a DC or AC current source supplied to the molten metal through electrodes and a source of constant or in-phase alternating vector-crossed magnetic field, or

b) induction type comprising a source of alternating magnetic field through a shorted loop of molten metal that induces an alternating current in the metal and a source of in-phase alternating vector-crossed magnetic field.

8. The power system of Claim 1 wherein the injector reservoir comprises an electrode in contact with the molten metal therein, and the non-injector reservoir comprises an electrode that makes contact with the molten metal provided by the injector system.

9. The power system of Claim 1 wherein the non-injector reservoir is aligned above (*e.g.*, vertically with) the injector and the injector is configured to produce the molten stream

orientated towards the non-injector reservoir such that molten metal from the molten metal stream may collect in the reservoir and the molten metal stream makes electrical contact with the non-injector reservoir electrode; and wherein the molten metal pools on the non-injector reservoir electrode.

10. The power system of Claim 1 wherein the vessel comprises an hourglass geometry (*e.g.*, a geometry wherein a middle portion of the internal surface area of the vessel has a smaller cross section than the cross section within 20% or 10% or 5% of each distal end along the major axis) and oriented in a vertical orientation (*e.g.*, the major axis of the vessel is approximately parallel with the force of gravity) in cross section wherein the injector reservoir is below the waist and configured such that the level of molten metal in the reservoir is about proximal to the waist of the hourglass to increase the ignition current density.

11. The power system of Claim 1 wherein the molten metal reacts with water to form atomic hydrogen.

12. The power system of Claim 1 wherein the molten metal is gallium and the power system further comprises a gallium regeneration system to regenerate gallium from gallium oxide (e.g., gallium oxide produced in the reaction).

13. The power system of Claim 1 wherein the power converter or output system is a magnetohydrodynamic converter comprising a nozzle connected to the vessel, a magnetohydrodynamic channel, electrodes, magnets, a metal collection system, a metal recirculation system, a heat exchanger, and optionally a gas recirculation system.

14. The power system of Claims 1, wherein the molten metal pump system comprises a first stage electromagnetic pump and a second stage electromagnetic pump, wherein the first stage comprises a pump for a metal recirculation system, and the second stage that comprises the pump of the metal injector system.

15. The power system of Claim 1 wherein the reaction produces a hydrogen product characterized as one or more of:

a) a hydrogen product with a Raman peak at one or more range of 1900 to 2000 cm^{-1} and 5500 to 6200 cm^{-1};

b) a hydrogen product with a plurality of Raman peaks spaced at an integer multiple of 0.23 to 0.25 eV;

c) a hydrogen product with an infrared peak at 1900 to 2000 cm^{-1};

d) a hydrogen product with a plurality of infrared peaks spaced at an integer multiple of 0.23 to 0.25 eV;

e) a hydrogen product with at a plurality of UV fluorescence emission spectral peaks in the range of 200 to 300 nm having a spacing at an integer multiple of 0.23 to 0.3 eV;

f) a hydrogen product with a plurality of electron-beam emission spectral peaks in the range of 200 to 300 nm having a spacing at an integer multiple of 0.2 to 0.3 eV;

g) a hydrogen product with a plurality of Raman spectral peaks in the range of 5000 to 20,000 cm^{-1} having a spacing at an integer multiple of 1000 ± 200 cm^{-1};

h) a hydrogen product with a continuum Raman spectrum in the range of 40 to 8000 cm^{-1};

i) a hydrogen product with a Raman peak in the range of 1500 to 2000 cm^{-1} due to at least one of paramagnetic and nanoparticle shifts;

j) a hydrogen product with a X-ray photoelectron spectroscopy peak at an energy in the range of 490 to 525 eV;

k) a hydrogen product that causes an upfield MAS NMR matrix shift;

l) a hydrogen product that has an upfield MAS NMR or liquid NMR shift of greater than -5 ppm relative to TMS;

m) a hydrogen product comprising macro-aggregates or polymers H_n (n is an integer greater than 3);

n) a hydrogen product comprising macro-aggregates or polymers H_n (n is an integer greater than 3) having a time of flight secondary ion mass spectroscopy (ToF-SIMS) peak of 16.12 to 16.13;

o) a hydrogen product comprising a metal hydride wherein the metal comprises at least one of Zn, Fe, Mo, Cr, Cu, and W;

p) a hydrogen product comprising at least one of H_{16} and H_{24};

q) a hydrogen product comprising an inorganic compound M_xX_y and H_2 wherein M is a cation and X in an anion having at least one of electrospray ionization time of flight secondary ion mass spectroscopy (ESI-ToF) and time of flight secondary ion mass spectroscopy (ToF-SIMS) peaks of $M(M_xX_yH_2)n$ wherein n is an integer;

r) a hydrogen product comprising at least one of $K_2CO_3H_2$ and $KOHH_2$ having at least one of electrospray ionization time of flight secondary ion mass spectroscopy (ESI-ToF) and time of flight secondary ion mass spectroscopy (ToF-SIMS) peaks of $K\left(K_2H_2CO_3\right)_n^+$ and $K\left(KOHH_2\right)_n^+$, respectively;

s) a magnetic hydrogen product comprising at least one of a metal hydride and a metal oxide further comprising hydrogen wherein the metal comprises at least one of Zn, Fe, Mo, Cr, Cu, W, and a diamagnetic metal;

t) a hydrogen product comprising at least one of a metal hydride and a metal oxide further comprising hydrogen wherein the metal comprises at least one of Zn, Fe, Mo, Cr, Cu, W, and a diamagnetic metal that demonstrates magnetism by magnetic susceptometry;

u) a hydrogen product comprising a metal that is not active in electron paramagnetic resonance (EPR) spectroscopy wherein the EPR spectrum comprises at least one of a g factor of about 2.0046 $\pm$20% and proton splitting such as a proton-electron dipole splitting energy of about 1.6 $X10^{-2}$ eV $\pm$20%;

v) a hydrogen product comprising a hydrogen molecular dimer $[H_2]_2$ wherein the EPR spectrum shows at least an electron-electron dipole splitting energy of about $9.9X10^{-5}$ eV $\pm$20% and a proton-electron dipole splitting energy of about 1.6 $X10^{-2}$ eV $\pm$20%;

w) a hydrogen product comprising a gas having a negative gas chromatography peak with hydrogen or helium carrier;

x) a hydrogen product having a quadrupole moment/e of $\frac{1.70127a_0^2}{p^2}\pm 10\%$ wherein p is an integer;

y) a protonic hydrogen product comprising a molecular dimer having an end over end rotational energy for the integer J to J + 1 transition in the range of (J+1)44.30 cm^{-1} ± 20 cm^{-1} wherein the corresponding rotational energy of the molecular dimer comprising deuterium is ½ that of the dimer comprising protons;

z) a hydrogen product comprising molecular dimers having at least one parameter from the group of (i) a separation distance of hydrogen molecules of 1.028 Å $\pm 10\%$, (ii) a vibrational energy between hydrogen molecules of 23 cm^{-1} $\pm 10\%$, and (iii) a van der Waals energy between hydrogen molecules of 0.0011 eV $\pm 10\%$;

aa) a hydrogen product comprising a solid having at least one parameter from the group of (i) a separation distance of hydrogen molecules of 1.028 Å ±10%, (ii) a vibrational energy between hydrogen molecules of 23 cm^{-1} ±10%, and (iii) a van der Waals energy between hydrogen molecules of 0.019 eV ±10%;

bb) a hydrogen product having FTIR and Raman spectral signatures of (i) (J+1)44.30 cm^{-1} ± 20 cm^{-1}, (ii) (J+1)22.15 cm^{-1} ± 10 cm^{-1} and (iii) 23 cm^{-1} $\pm 10\%$ and/or an X-ray or neutron diffraction pattern showing a hydrogen molecule separation of 1.028 Å ±10% and/or a calorimetric determination of the energy of vaporization of 0.0011 eV ±10% per molecular hydrogen;

cc) a solid hydrogen product having FTIR and Raman spectral signatures of (i) (J+1)44.30 cm^{-1} ±10% cm^{-1}, (ii) (J+1)22.15 cm^{-1} ±10% cm^{-1} and (iii) 23 cm^{-1} ±10% and/or an X-ray or neutron diffraction pattern showing a hydrogen molecule separation of 1.028 Å ±10% and/or a calorimetric determination of the energy of vaporization of 0.019 eV ±10% per molecular hydrogen.

dd) a hydrogen product comprising a hydrogen hydride ion that is magnetic and links flux in units of the magnetic in its bound-free binding energy region;

ee) a hydrogen product wherein the high pressure liquid chromatography (HPLC) that shows chromatographic peaks having retention times longer than that of the carrier void volume time using an organic column with a solvent comprising water wherein the detection of the peaks by mass spectroscopy such as ESI-ToF shows fragments of at least one inorganic compound.