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Supplementary Information

Highly Efficient, Coking-Resistant SOFCs for Energy Conversion Using Biogas Fuels

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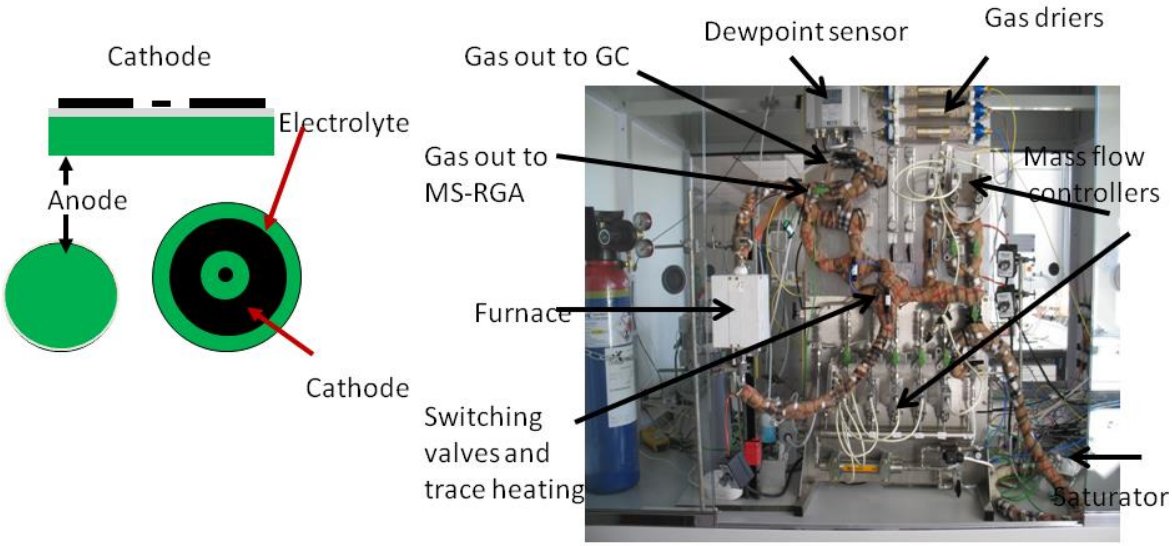
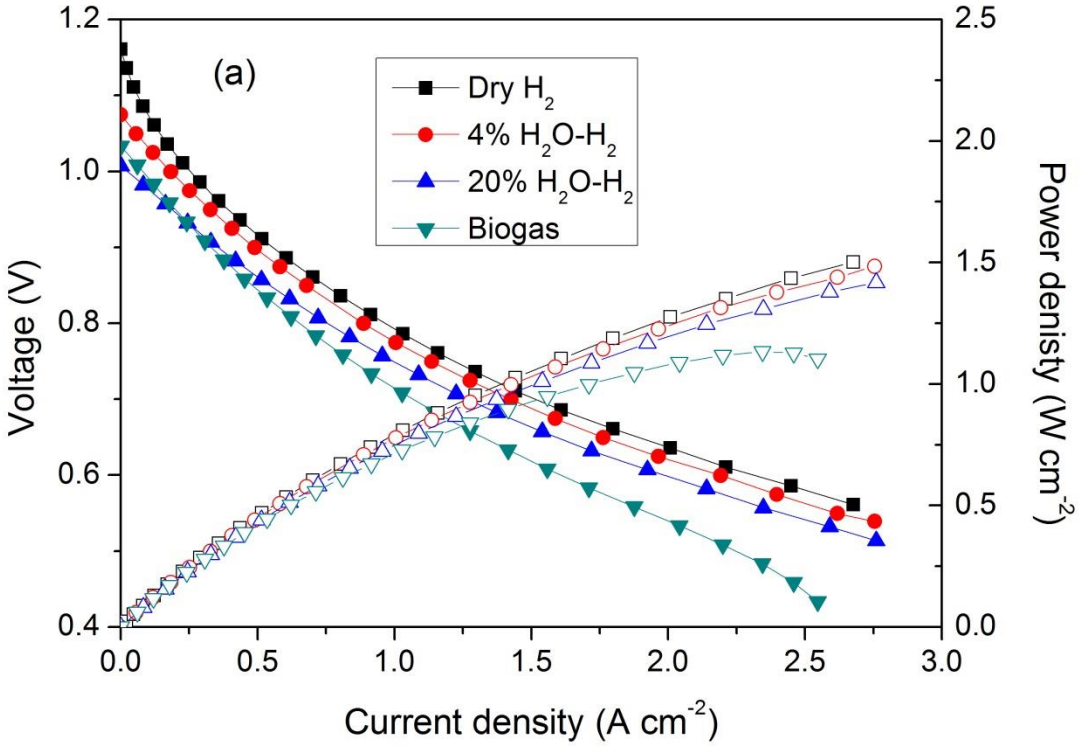
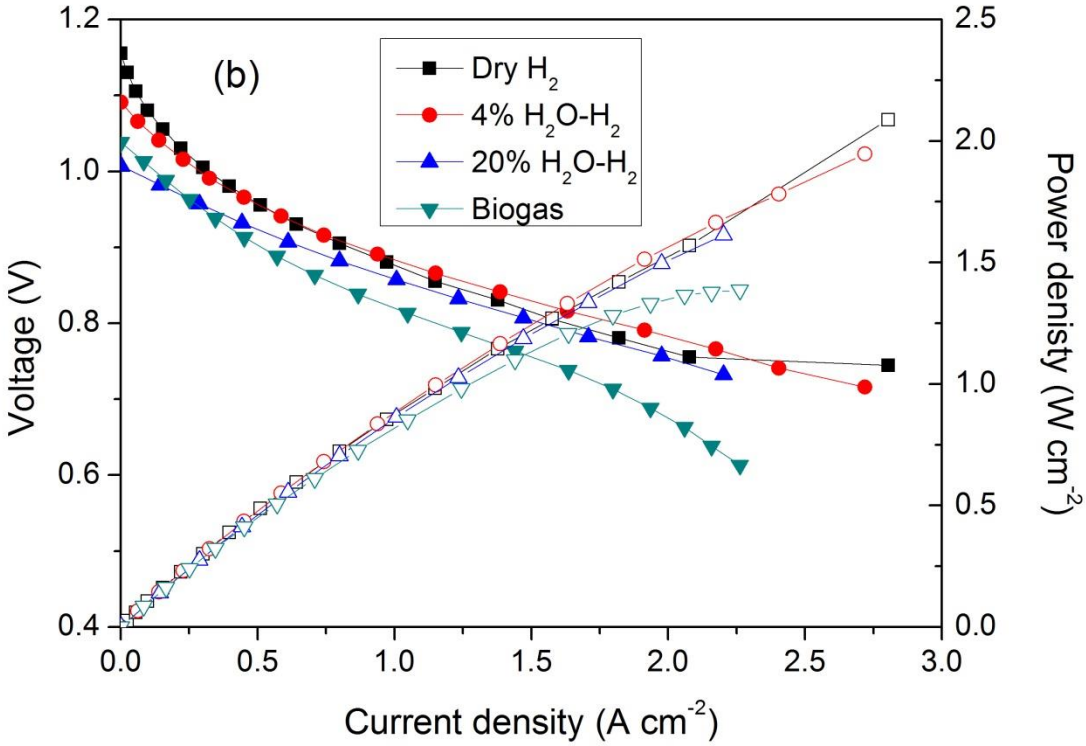
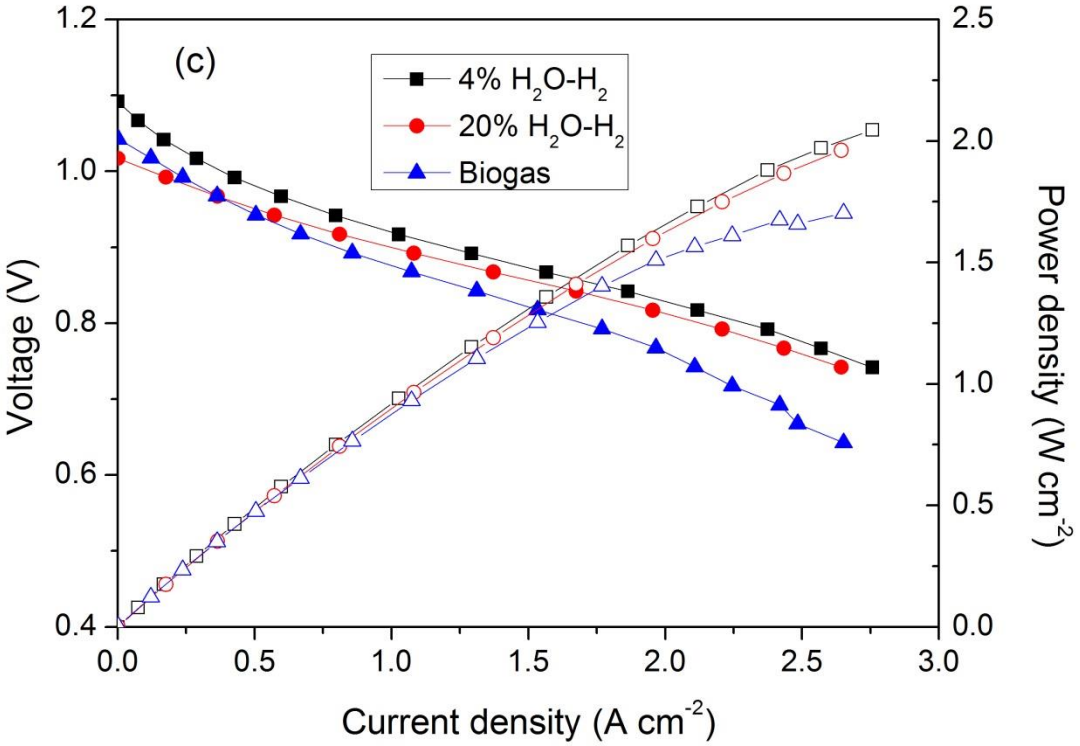
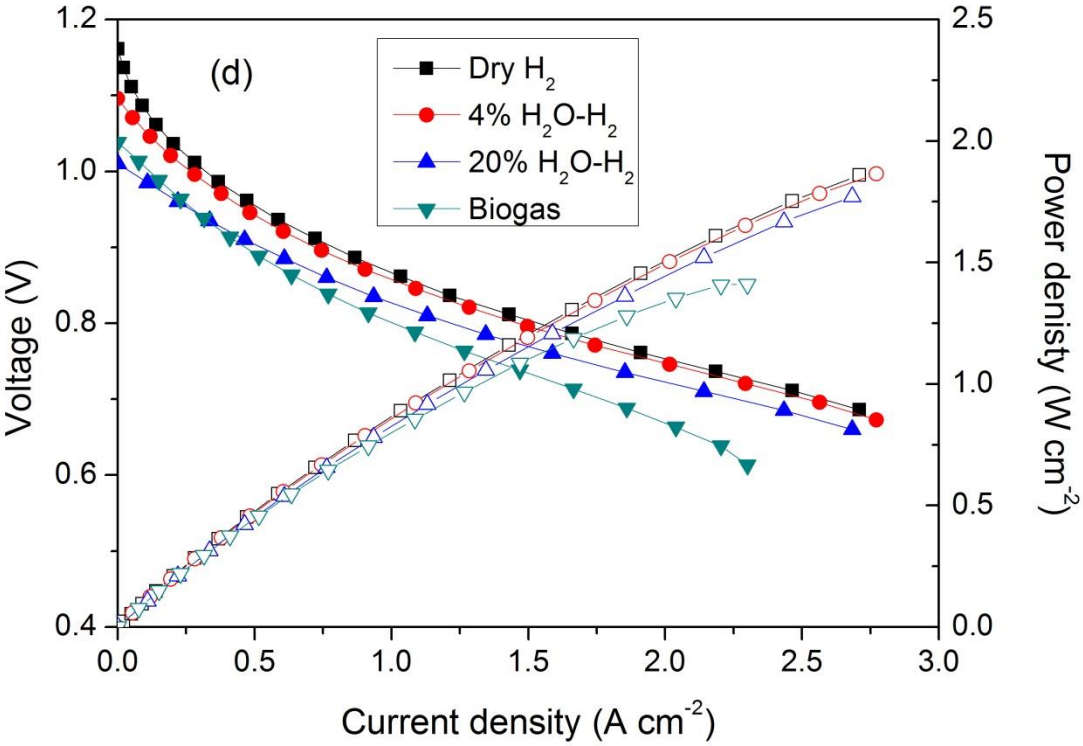


Fig. S1. Schematic diagram of the cell structure and test rig


(a)
Dry H2
4% H2O-H2
20% H2O-H2
Biogas
Voltage (V)
Power denisty (W cm-2)
Current density (A cm-2)
1.2
1.0
0.8
0.6
0.4
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0


(b)
Dry H2
4% H2O-H2
20% H2O-H2
Biogas
Voltage (V)
Power denisty (W cm-2)
Current density (A cm-2)
1.2
1.0
0.8
0.6
0.4
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0


(c)
4% H2O-H2
20% H2O-H2
Biogas
Voltage (V)
Power density (W cm-2)
Current density (A cm-2)
1.2
1.0
0.8
0.6
0.4
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0


(d)
Dry H2
4% H2O-H2
20% H2O-H2
Biogas
Voltage (V)
Power denisty (W cm-2)
Current density (A cm-2)
1.2
1.0
0.8
0.6
0.4
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0

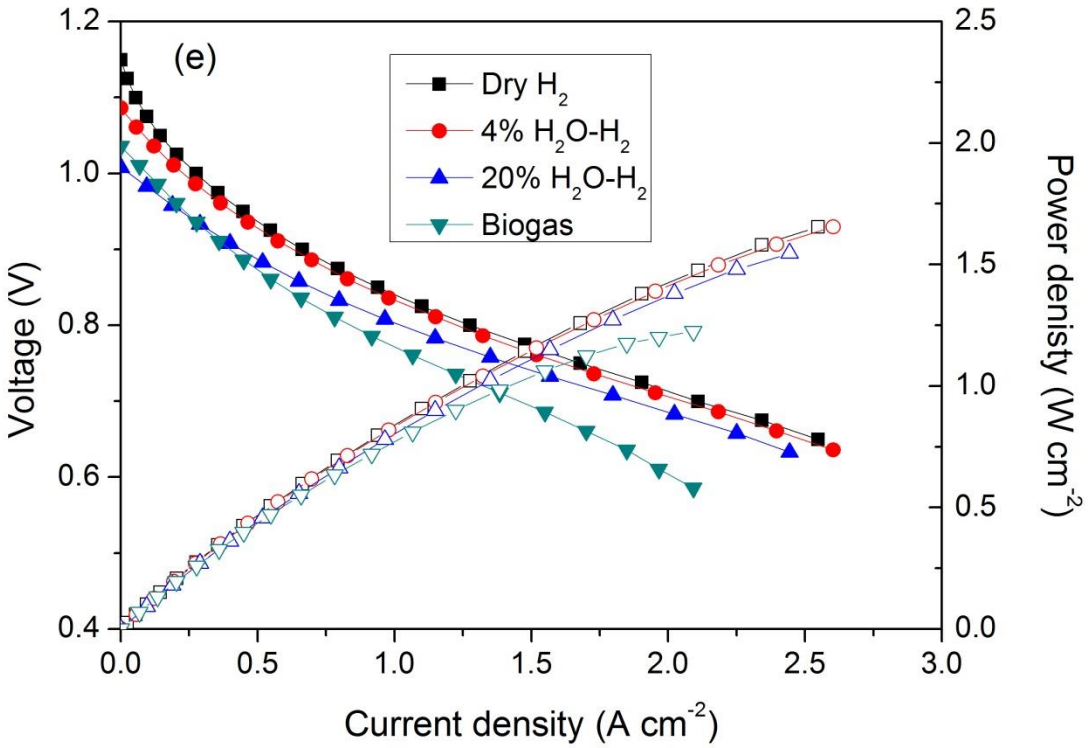


Fig. S2. The cell performance of an anode-supported cell in pure hydrogen, 4%H_2O-hydrogen, 20%H_2O-hydrogen and the recirculated biogas at 800 °C; the cell was composed of a YSZ thin film electrolyte, a LSM-YSZ composite cathode and a 1 mm Ni-YSZ infiltrated with different amounts of BCZYYb (a) BCZYYb-0; (b) BCZYYb-0.3 wt%; (c) BCZYYb-0.6 wt%; (d) BCZYYb-1.0 wt%; (e) BCZYYb-1.6 wt%

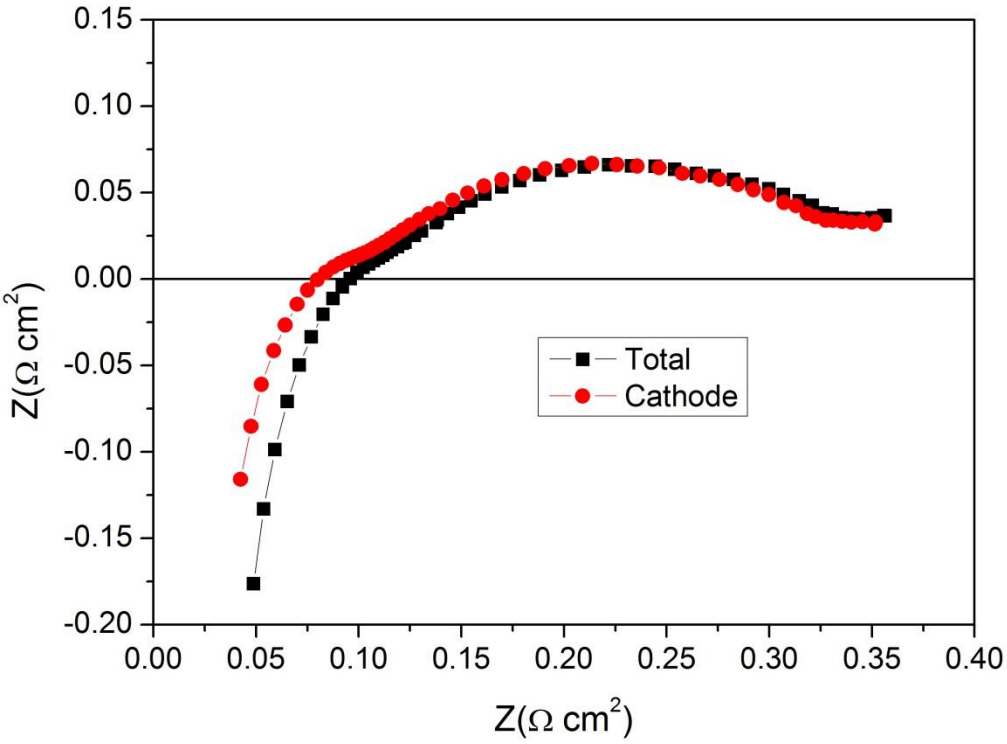


Fig. S3. Impedance spectra of the cell and the cathode, the cell has a structure of BCZYYb-0.6 wt% -Ni-YSZ/YSZ/GDC/LSCF-GDC, and the cathode impedance spectra was tested with three electrode mode shown in Fig. S1.

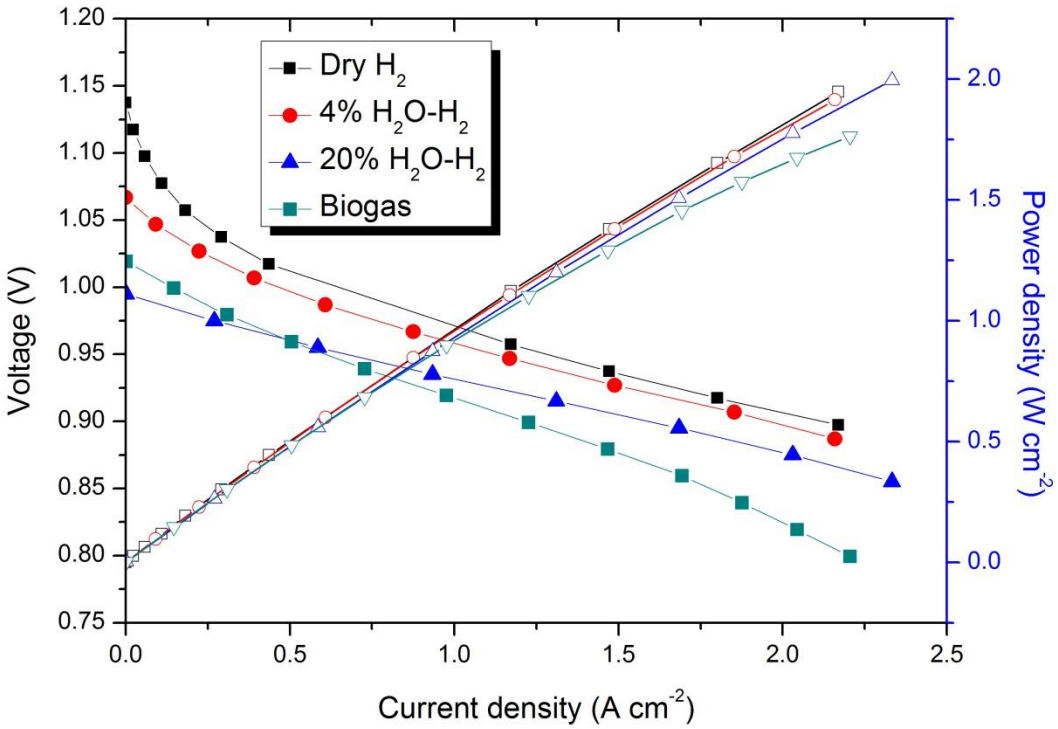


Fig. S4. The cell performance of an anode-supported cell in pure hydrogen, 4%H_2O-hydrogen, 20%H_2O-hydrogen and the recirculated biogas at 850 °C. The cell was composed of a BCZYYb-0.6 wt%-1 mm Ni-YSZ, a 3 µm YSZ electrolyte, a GDC buffer layer and a LSCF-GDC.

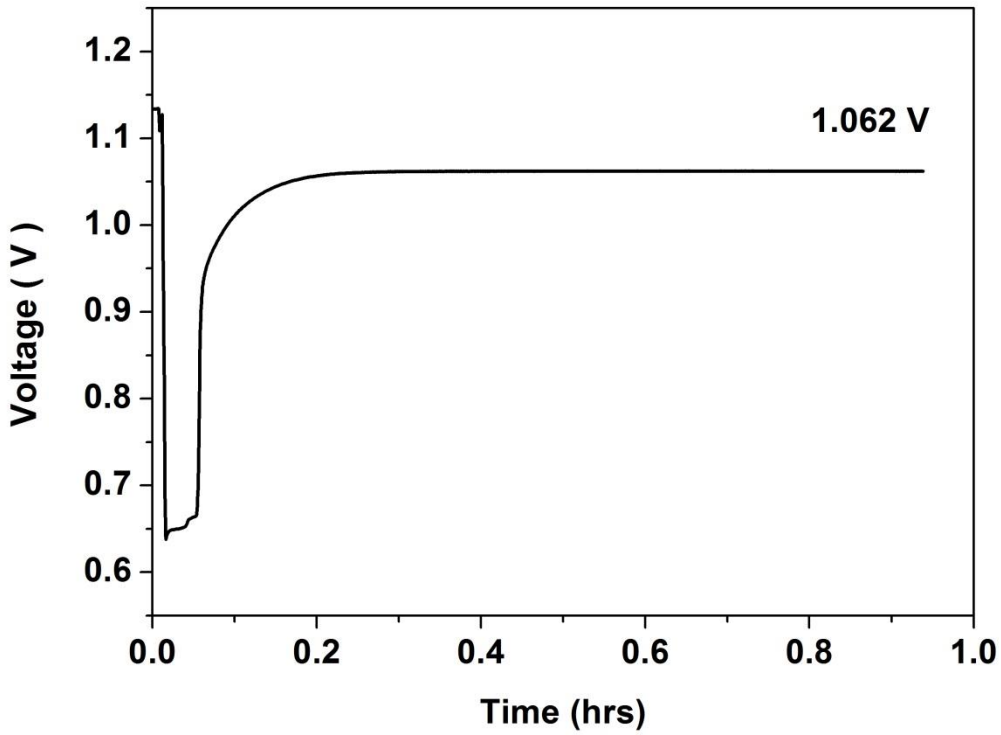


Fig. S5. The open circuit voltage of an anode-supported cell of a 1 mm Ni-YSZ, a YSZ thin film electrolyte, a GDC buffer layer and a LSCF-GDC, operating in pure hydrogen to 4%H_2O-hydrogen (room temperature 25 °C). The OCV of the cell in hydrogen was 1.13 V and decreased 0.65 V during the switchover to 4%H_2O-hydrogen and then became to be stable in 1.06 V in one hour.

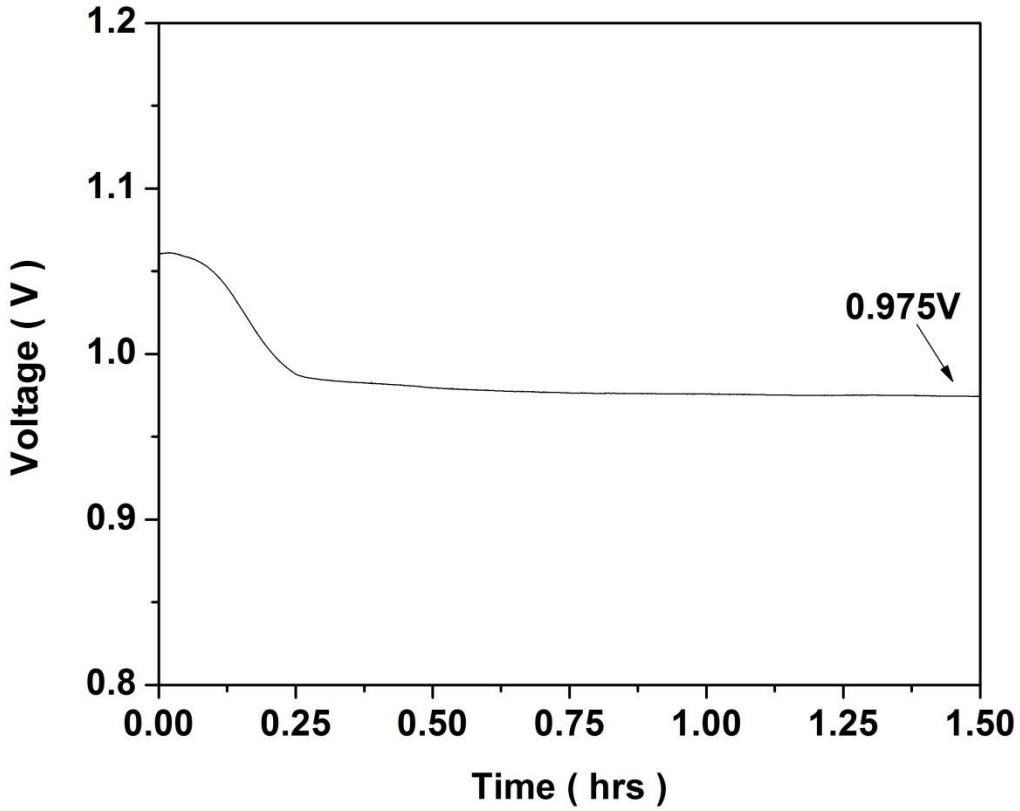


Fig. S6. The open circuit voltage of an anode-supported cell of a 1 mm Ni-YSZ, a YSZ thin film electrolyte, a GDC buffer layer and a LSCF-GDC, operating in 4%H_2O-hydrogen to 20% H_2O-hydrogen, the OCV of the cell was 1.06 V in 4%H_2O-hydrogen and started to decrease in 20% H_2O-hydrogen and stabilised at 0.975 V.

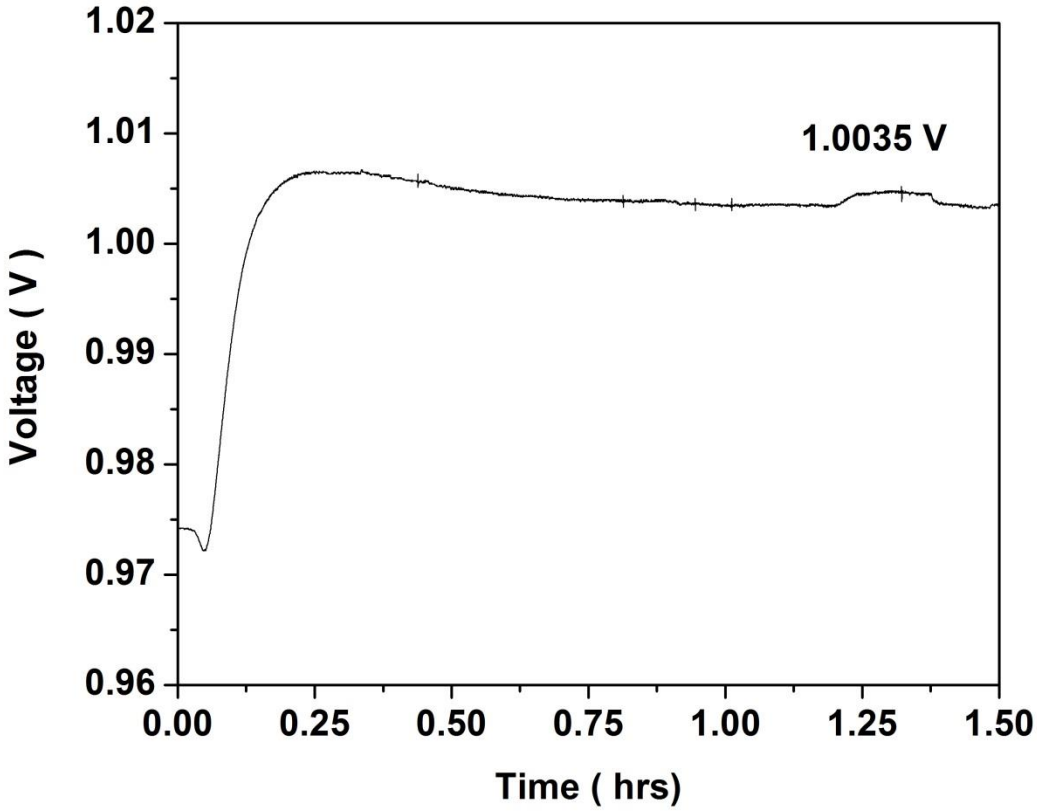


Fig. S7. The open circuit voltage of an anode-supported cell of a 1 mm Ni-YSZ, a YSZ thin film electrolyte, a GDC buffer layer and a LSCF-GDC, operating in 20% H_2O-hydrogen, changes to the recirculated biogas, the OCV of the cell in 20% H_2O-hydrogen was 0.975 V increased to 1.00 V.

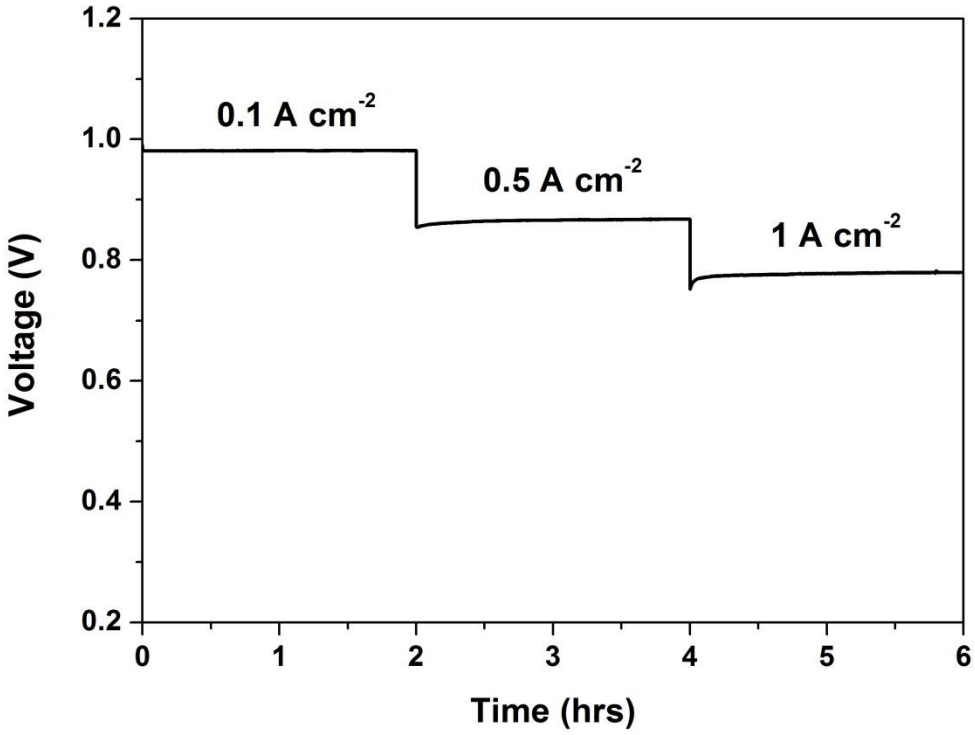


Fig. S8. Cell voltage at different currents (0.1 A cm^{-2}, 0.5 A cm^{-2} and 1 A cm^{-2}) supplied with 20 ml min^{-1} biogas, testing temperature was 850 °C, the cell was composed of a 1 mm Ni-YSZ, a YSZ thin film electrolyte, a LSM-YSZ composite cathode.