Electronic Supplementary Information

Single-component fuel cells fabricated by Spark Plasma Sintering

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Preparation of electron conducting material

For the preparation of electron conducting material the following chemicals, all from Sigma-Aldrich Company were used:

6.75 g of $Ce(N0_3)_3 \cdot 6H_20$
0.75 g of $Sm(N0_3)_3 \cdot 6H_20$
1.25 g of $Zn(N0_3)_2 \cdot 6H_20$
1.00 g of $Sr(N0_3)_2$
1.575 g of Li_2CO_3
8.25 g of $NiCO_3 \cdot 2Ni(OH)_2 \cdot xH_2O$
2.525 g of $CuCO_3 \cdot Cu(OH)_2$
0.0125g of $SrCO_3$

Solid state reaction method has been used with one time intermediate grindings at 800 ^oC for 4 h.

Preparation of ionic conducting material

For the preparation of ionic conducting material the following chemicals, all from Sigma-Aldrich Company were used:

23.2 g of $Sm(N0_3)_3 \cdot 6H_20$

87 g of $Ce(N0_3)_3 \cdot 6H_20$
53.5 g of $NaCO_3$

The co-precipitation method was used. The above amounts of $Sm(N0_3)_3 \cdot 6H_20$, $Ce(N0_3)_3 \cdot 6H_20$, $NaCO_3$ were mixed in 5L of H_2O and in parallel above amount of $NaCO_3$ was mixed in 1 L of H_2O, then 1 L of Na_2CO_3 solution was added slowly (with a flow rate of 100 ml min) into the solution under vigorous stirring to form white precipitation. After stirring for 3 h, the precipitate was filtered and dried at 100 ^oC for 20h to obtain the final ionic conducting material.

Spark Plasma Sintering (SPS) principle

A schematic of the SPS setup is shown in Fig5. The SPS method has been used in this work for fabrication of single-component fuel cells. An amount of ~0.80g single component powder has been used for each fabricated cell. The powder (yellow color) was loaded into a 20 mm diameter graphite die. Both sides of the loaded powder were covered by silver coated meshes which play the role of current collectors (blue colour). To obtain a good flatness of the sintered samples, stainless steel plates have been used as separators between the meshes and graphite punches. The SPS chamber was then evacuated until 4 Pa have been reached. The sintering was performed using a sequence of 12:2 on/off pulses (12 pulses of DC current followed by 2 set of time periods with no current, each period being 6ms long). A heating rate of 50 ^{o}C / min has been used for all the fabricated cells. The applied pressure was adjusted during heating up to the desired plateau temperature and kept at a constant value for 5 minutes.

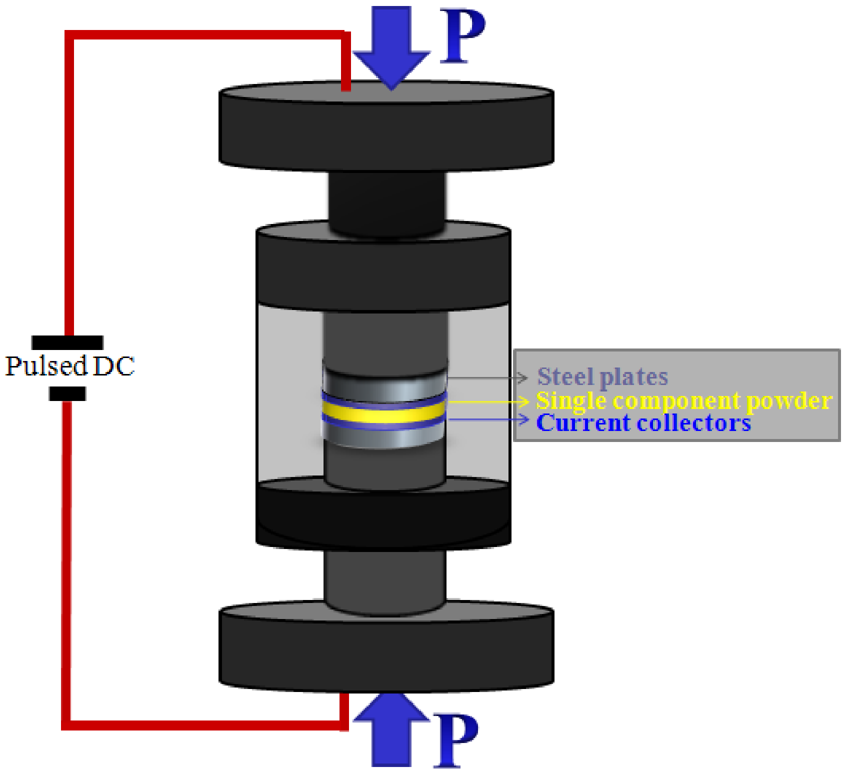

Fig.5 Schematics of the SPS method used for fabrication of single-component fuel cells.

Cross-section of ionic conducting material

Cross section SEM micrographs of a fuel cell sintered at 550 ^{o}C are shown in Fig.6 The materials consist of three parts; (*i*) a homogeneous layer in a mixture of electronic- and ionic conductivity material surrounded by (*ii*) top and (*iii*) lower layers consisting of coated silver meshes used as current collectors. It is clear from the micrographs that the samarium doped CeO_2/Na_2CO_3 - $Li_{2x}Zn_{1-x}O$/NiO/SrO/CuO/ sintered composite possess a structure with each of the current collectors well embedded into the single component layer as required for a good current collector path.

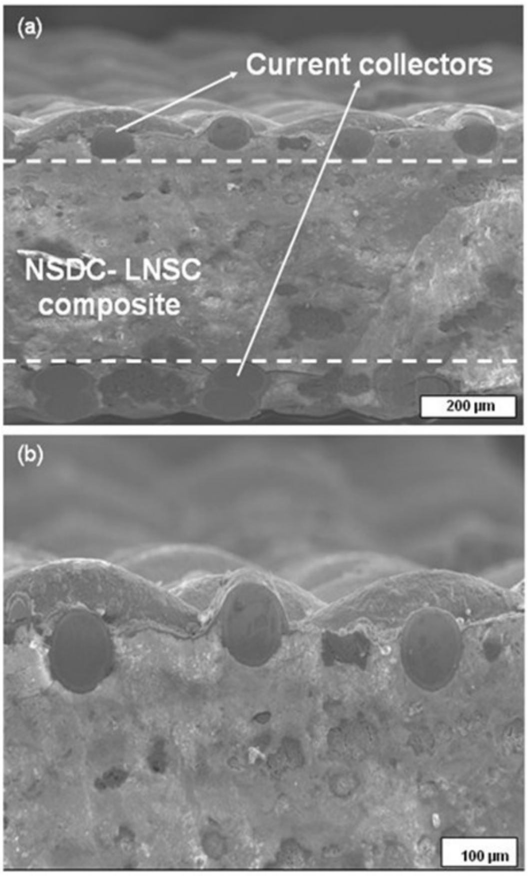

Fig.6 Cross-section SEM images of **(a)** a single-component fuel cell fabricated at 550 °C.

(b) Detail of the interface between the current collector (Ag net) and the samarium doped $CeO_2/Na_2CO_3 – Li_{2x}Zn_{1-x}O/NiO/SrO/CuO/$ composite