

**Electronic Supplementary Information**

**Direct Methane Fuel Cell with  $\text{La}_2\text{Sn}_2\text{O}_7\text{-Ni-Gd}_{0.1}\text{Ce}_{0.9}\text{O}_{1.95}$  Anode and Electrospun  
 $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2}\text{Fe}_{0.8}\text{O}_{3-\delta}\text{-Gd}_{0.1}\text{Ce}_{0.9}\text{O}_{1.95}$  Cathode**

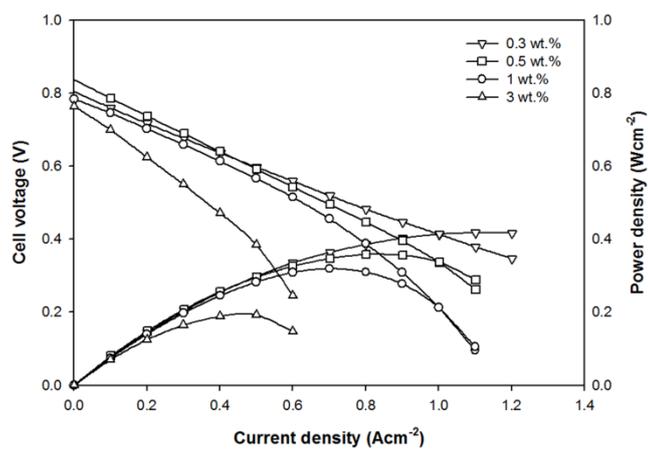
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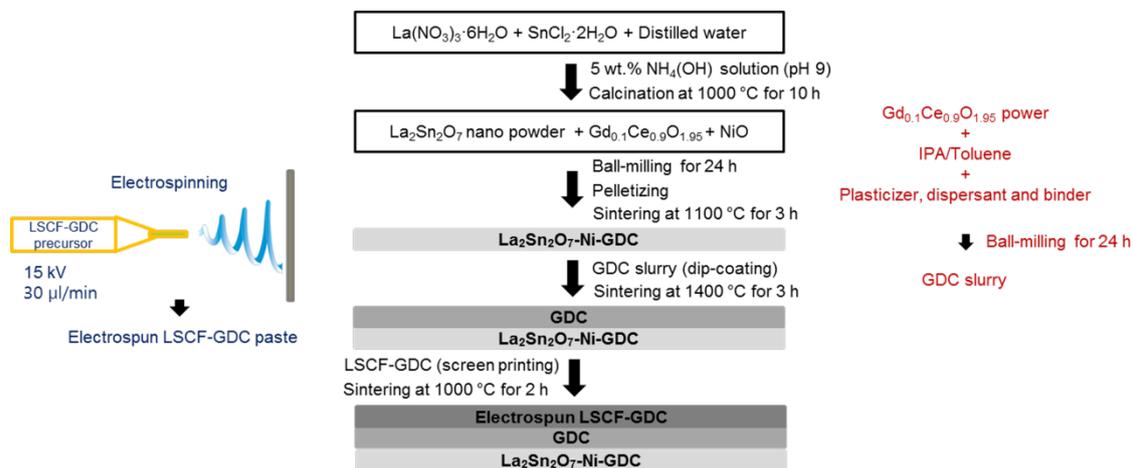
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## Supplementary Figures



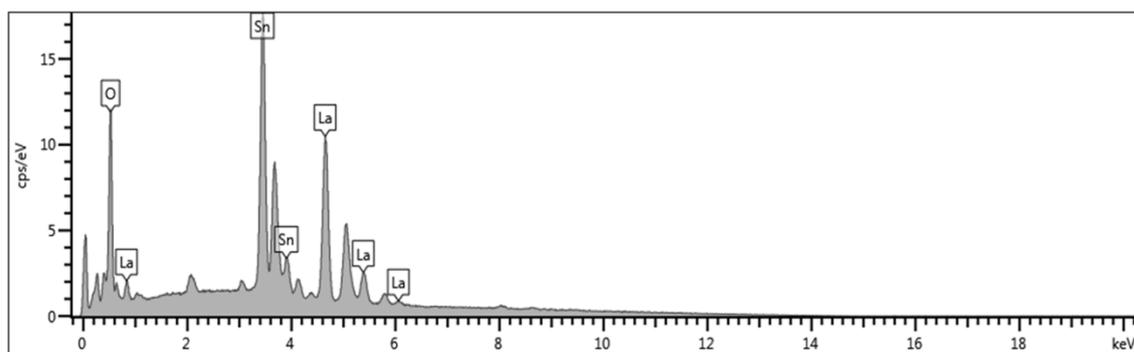
**Figure S1.** I-V curves of the  $\text{La}_2\text{Sn}_2\text{O}_7$ -Ni-GDC/GDC/conventional LSCF-GDC cell depending on the weight ratio of  $\text{La}_2\text{Sn}_2\text{O}_7$  to NiO at 650 °C ( $\text{CH}_4$ : 25sccm and Air 300 sccm)



**Figure S2.** Synthesis and fabrication process of the  $\text{La}_2\text{Sn}_2\text{O}_7$  power and  $\text{La}_2\text{Sn}_2\text{O}_7$ -Ni-GDC/GDC/electrospun LSCF-GDC cell

**Table S1.** The elemental composition of the  $\text{La}_2\text{Sn}_2\text{O}_7$ ,  $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2}\text{Fe}_{0.8}\text{O}_{3-\delta}$ , and  $\text{Gd}_{0.1}\text{Ce}_{0.9}\text{O}_{1.95}$  powders used in this study

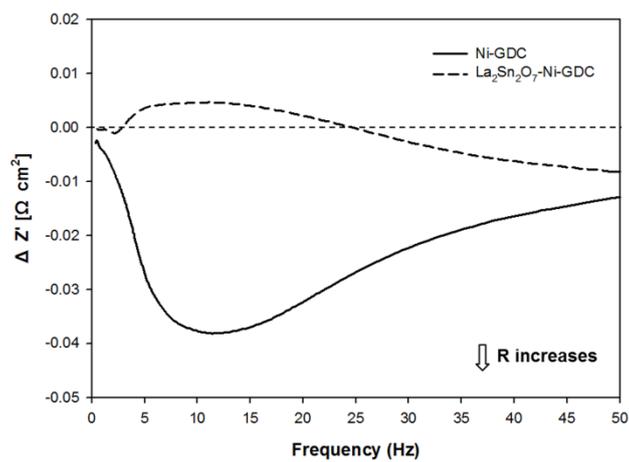
| Atomic fraction of:   | La     | Sn     | Sr   | Co   | Fe   | Gd   | Ce   | O              |
|---|--------|--------|------|------|------|------|------|----------------|
| $\text{La}_2\text{Sn}_2\text{O}_7$<br>(Sol-gel synthesis)   | 0.1742 | 0.1739 |      |      |      |      |      | 0.6519         |
| $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2}\text{Fe}_{0.8}\text{O}_{3-\delta}$<br>(Inframmat Advanced Materials) | 0.12   |        | 0.08 | 0.04 | 0.16 |      |      | 0.6 - $\delta$ |
| $\text{Gd}_{0.1}\text{Ce}_{0.9}\text{O}_{1.95}$<br>(Rhodia)   |        |        |      |      |      | 0.03 | 0.31 | 0.66           |



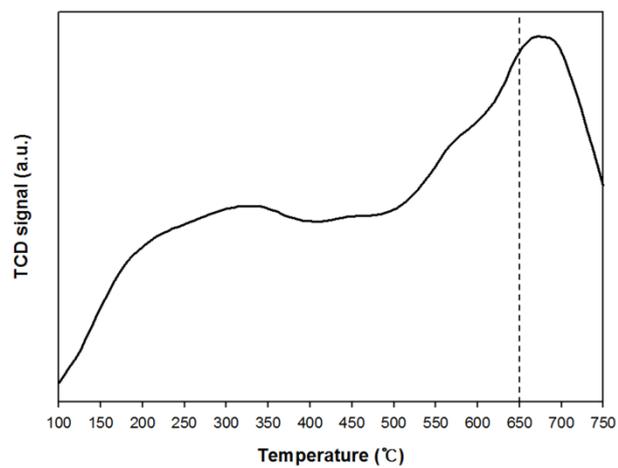
**Figure S3.** Energy-dispersive X-ray spectroscopy (EDX) data of the  $\text{La}_2\text{Sn}_2\text{O}_7$  power calcined at 1000 °C in air

**Table S2.** Impedance model for the  $\text{La}_2\text{Sn}_2\text{O}_7$ -Ni-GDC anode-supported cell with the electrospun LSCF-GDC cathode and the Ni-GDC anode-supported cell with the conventional LSCF-GDC cathode <sup>[1]</sup>

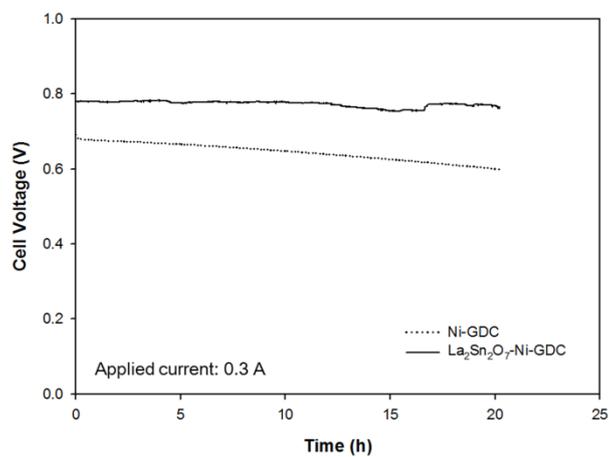
| Summit frequency of: | ( $R_{\text{Cathode, High } Q_1}$ )      | ( $R_{\text{Anode, TPB } Q_2}$ )   | ( $R_{\text{Cathode, Low } Q_3}$ )  | ( $R_{\text{Anode, Diff } Q_4}$ ) | ( $R_{\text{Anode, Conv } Q_5}$ ) |
|----------------------|--|--|---|-----------------------------------|-----------------------------------|
| 700 °C               | ~18 kHz                                  | ~1 kHz   | ~100 Hz   | ~50 Hz                            | ~3 Hz                             |
| Interpretation:      | Charge transfer at the cathode interface | Charge transfer of the anode and diffusion of charged species at the TPB | Dissociative adsorption, transfer of species at the TPB and surface diffusion | Gas diffusion                     | Gas conversion                    |



**Figure S4.** ADIS plots of the  $\text{La}_2\text{Sn}_2\text{O}_7$ -Ni-GDC anode-supported cell with the electrospun LSCF-GDC cathode and the Ni-GDC anode-supported cell with the conventional LSCF-GDC cathode at 650 °C when the fuel is changed from hydrogen to methane



**Figure S5.** Temperature-programmed reduction (TPR) data of La<sub>2</sub>Sn<sub>2</sub>O<sub>7</sub> in a flow rate of 50 sccm of mixed gas (methane: 10 % and helium: 90 %) and a temperature range from 100 °C to 750 °C



**Figure S6.** Voltage variation of the La<sub>2</sub>Sn<sub>2</sub>O<sub>7</sub>-Ni-GDC anode-supported cell with the electrospun LSCF-GDC cathode and the Ni-GDC anode-supported cell with the conventional LSCF-GDC cathode at 650 °C in methane fuel (applied current: 0.3 A, methane and air flow rate: 25 sccm and 300 sccm, respectively)

## References

1. J. Nielsen and M. Mogensen, *Solid State Ionics*, 2011, *189*, 74-81