Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Investigating the effect of rGO on microstructural and electrical properties of $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ at intermediate temperature SOFCs

Muhammad Bilal Hanif,*[a] Sajid Rauf, [b] Sana Qayyum, [c] Marcel Šihor, [d] and Martin Motola,*[a]

[a]Department of Inorganic Chemistry, Faculty of Natural Sciences, Comenius University in Bratislava, Ilkovicova 6, 842 15 Bratislava, Slovakia.
[b]College of Electronics and Information Engineering, Shenzhen University, Guangdong Province, 518000, China
[c]Department of Chemistry & Chemical Engineering, Lahore University of Management Sciences (LUMS), Pakistan
[d]Institute of Environmental Technology, CEET, VŠB-Technical University of Ostrava, 17. listopadu 15, Ostrava-Poruba, Czech Republic

*Corresponding authors:
Muhammad Bilal Hanif hanif1@uniba.sk; muhammadbilal@stu.xjtu.edu.cn
Martin Motola ✉ martin.motola@uniba.sk; ☎ + 421 2 9014 9374

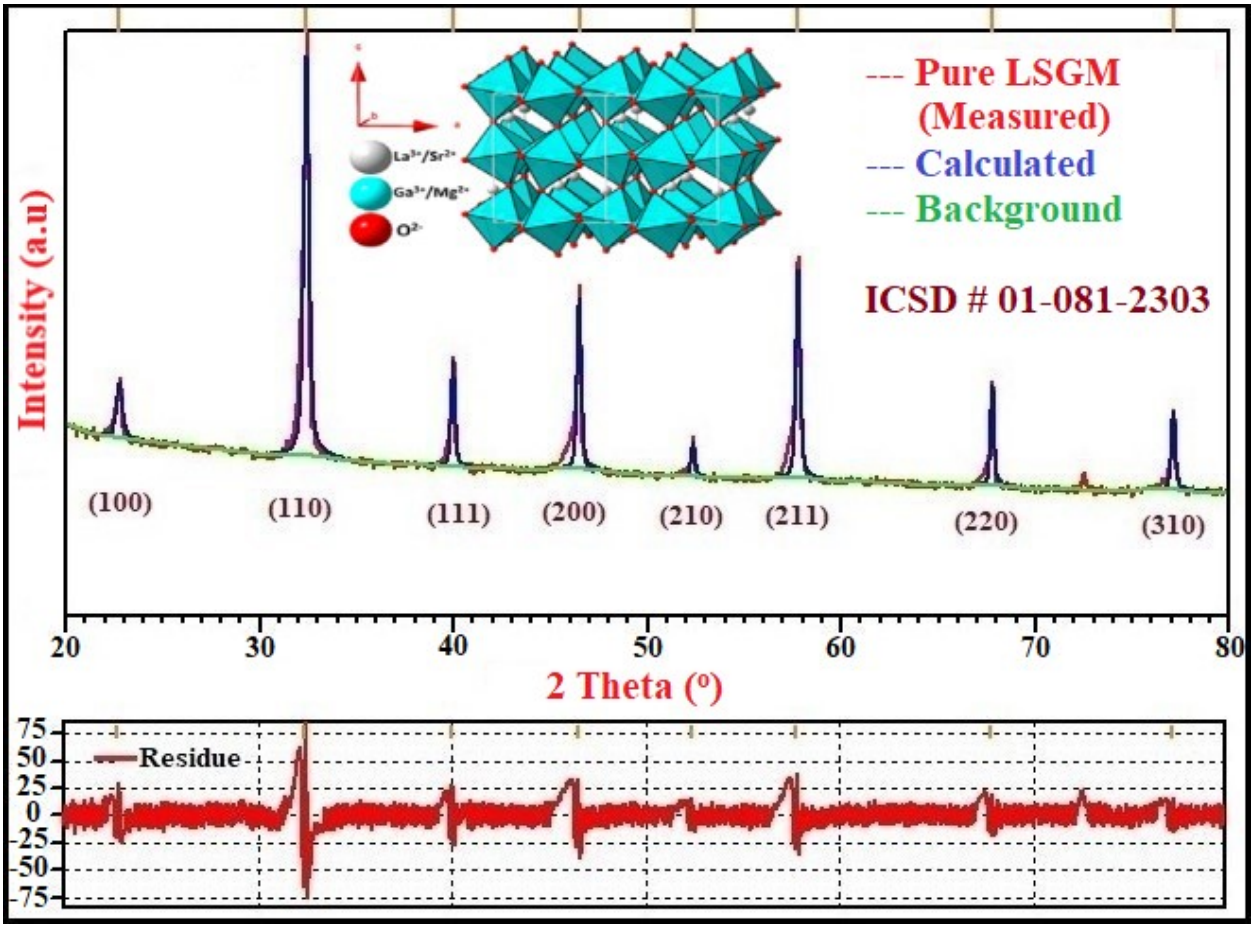

Figure S1. XRD Rietveld refinement spectra of LSGM powder held at 1450 °C for 5 hrs

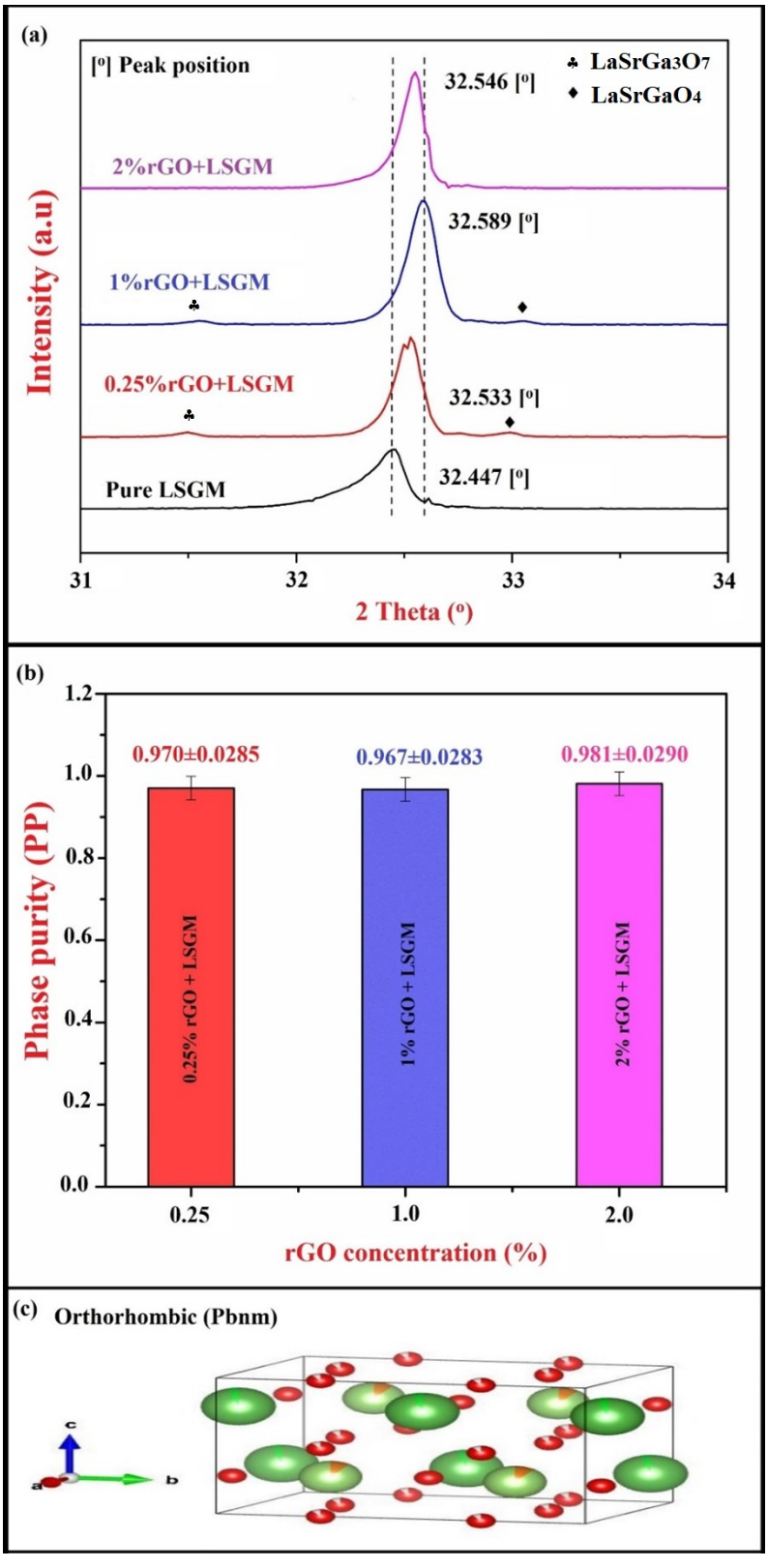
(a)
[º] Peak position
32.546 [º]
♣ LaSrGa3O7
♦ LaSrGaO4
2%rGO+LSGM
32.589 [º]
1%rGO+LSGM
0.25%rGO+LSGM
32.533 [º]
Pure LSGM
32.447 [º]
Intensity (a.u)
31
32
33
34
2 Theta (º)
(b)
0.970±0.0285
0.967±0.0283
0.981±0.0290
Phase purity (PP)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.25% rGO + LSGM
1% rGO + LSGM
2% rGO + LSGM
0.25
1.0
2.0
rGO concentration (%)
(c)
Orthorhombic (Pbnm)
c
a
b

Figure S2. Magnified XRD pattern for **(a).** x% rGO+LSGM in the 2-Theta range of (31°-34°) **(b).** phase purity bar-graph of rGO+ LSGM at different concentrations **(c).** orthorhombic structure.

The electrochemical performance of the fuel cell device was evaluated in terms of current and voltage (I-V) and current and power density (I-P) characteristics. An electronic load IT8511 (ITECH Electrical Co., Ltd., China) was employed to record the data through a software of IT7000 at a scan speed of 0.02 As^{-1} under a current-voltage sweep in the temperature range of 700-500 °C. Dry hydrogen gas served as fuel with a flow rate of (120-150 mL min^{-1}) in order to study the impedance and electrical properties of various components of fuel cell devices. The cells with the configuration of Ni-GDC/LSGM|LSCF-2%rGO-LSGM were assembled for this comparative study. We used Ni-GDC as an anode and LSCF-2%rGO-LSGM as cathode for measuring the fuel cell performance. The cell is then coated with a silver paste as a current collector and for gas sealing before being installed into the testing jig.

We have performed the multiple experiments for checking the electrochemical performance and durability of composites. We choose the best samples (i.e., rGO+2%LSGM) for checking the electrochemical experiment with significant power density along with considerable OCV (which follows the nerst equation and is in accordance with the other research [1-3]) at temperature between 500-700 °C in H_2/Air respectively. In **Fig. S3(a),** the fuel cell-based on Ni-GDC/LSGM|LSCF-2%rGO-LSGM electrolyte yielded a maximum power density of 0.539 Wcm^{-2} at 700 °C. Whereas the obtained durability test for 20 hrs is presented after transient conditions as shown **Fig. S3(b).**

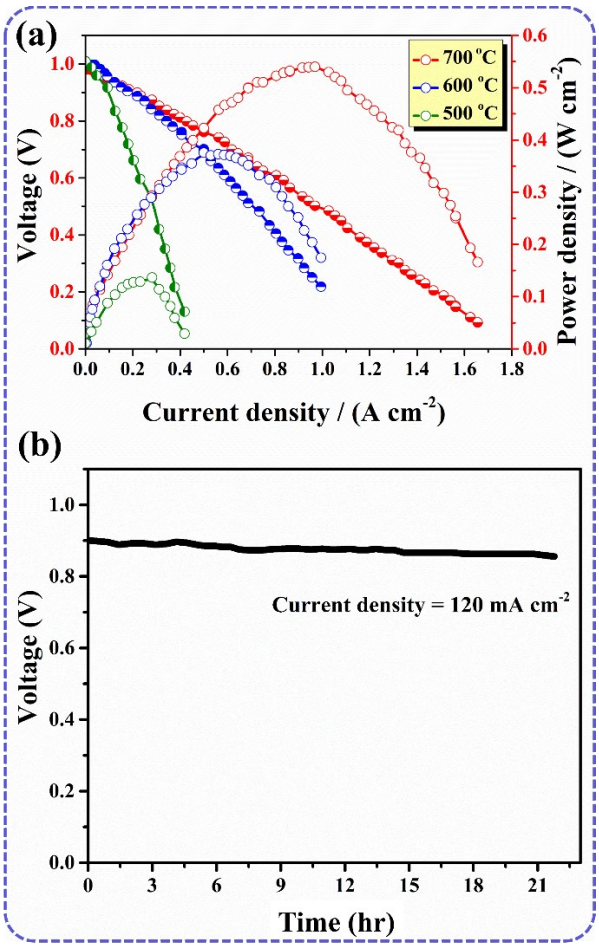

Figure S3: The electrochemical performance in terms of I-V and I-P curves for the rGO-2%LSGM cell **(a);** Durability operation of fuel cell device under a current density of 120 m Acm^{-2} at 700 ^{o}C **(b).**

References

1. C. S. Hwang, T. J. Hwang, C. H. Tsai, C. L. Chang, S. F. Yang, M. H. Wu, & C. Y. Fu, Ceramics International, 2017, 43, S591-S597.
2. H. Ishikawa, M. Enoki, T. Ishihara, & T. Akiyama, Journal of alloys and compounds, 2007, 430, 1-2, 246-251.
3. M. Shi, Y. Xu, A. Liu, N. Liu, C. Wang, P. Majewski, & F. Aldinger, Materials Chemistry and Physics, 2009, 114, 1, 43-46.