Supporting Information

Shufeng Song,*[a] Fengkun Wei,[a] Wei Xue,[a] Yanming Cui,[b] Zhixu Long,[a] Hongyang Shan[a] and Ning Hu*[c]

[a] College of Aerospace Engineering, Chongqing University, Chongqing 400044, China. E-mail: sfsong@cqu.edu.cn

[b] Zhejiang Funlithium New Energy Technology Co., Ltd., Ningbo, Zhejiang 315201, China

[c] School of Mechanical Engineering, Hebei University of Technology, Tianjin 300401, China. E-mail: ninghu@hebut.edu.cn

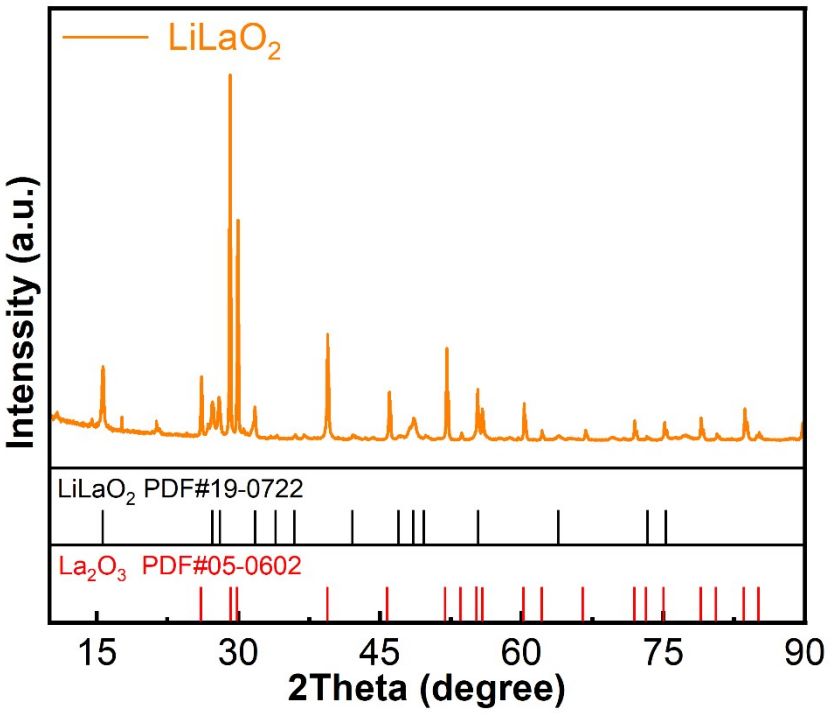

Fig. S1 XRD pattern of as-prepared $LiLaO_2$ with standard PDF cards.

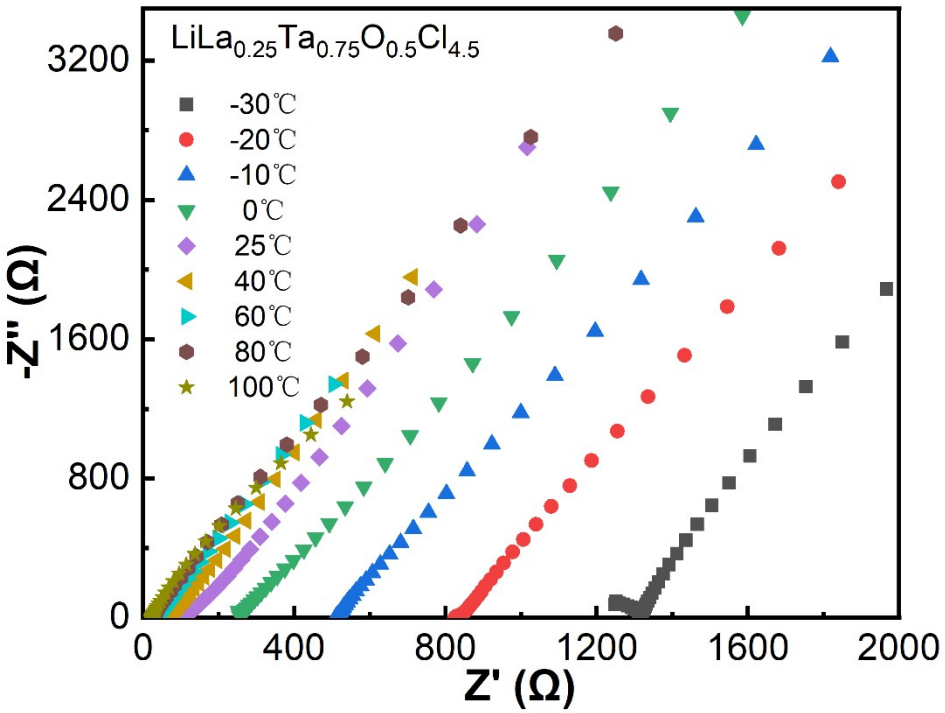

Fig. S2 Nyquist profiles for $LiLa_{0.25}Ta_{0.75}O_{0.5}Cl_{4.5}$ in the temperature range of -30 °C and 100 °C.

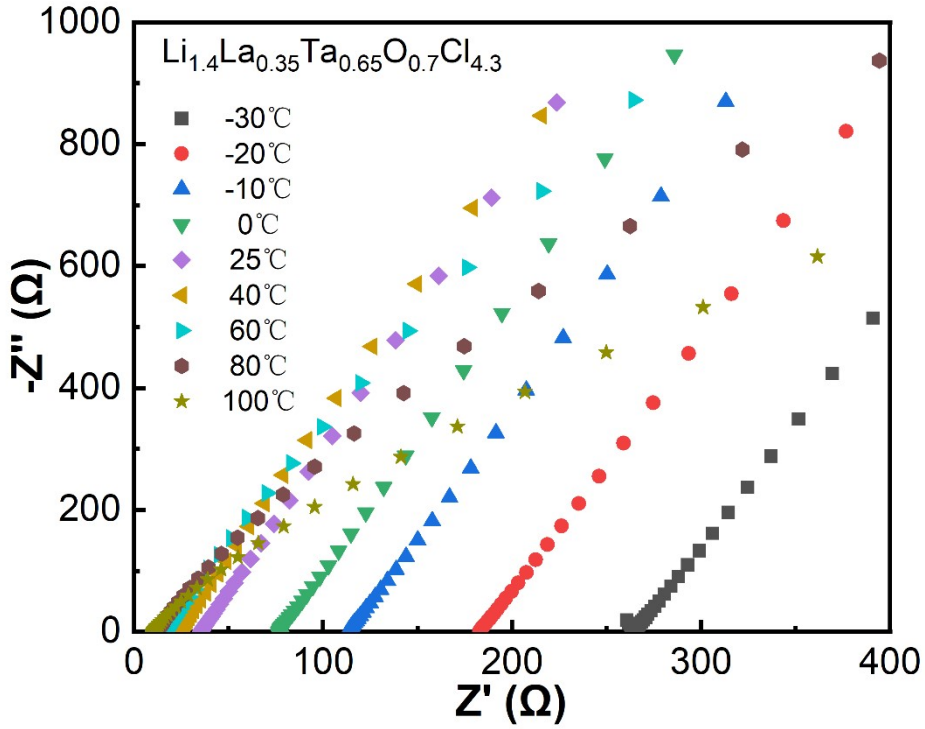

Fig. S3 Nyquist profiles for $Li_{1.4}La_{0.35}Ta_{0.65}O_{0.7}Cl_{4.3}$ in the temperature range of -30 °C and 100 °C.

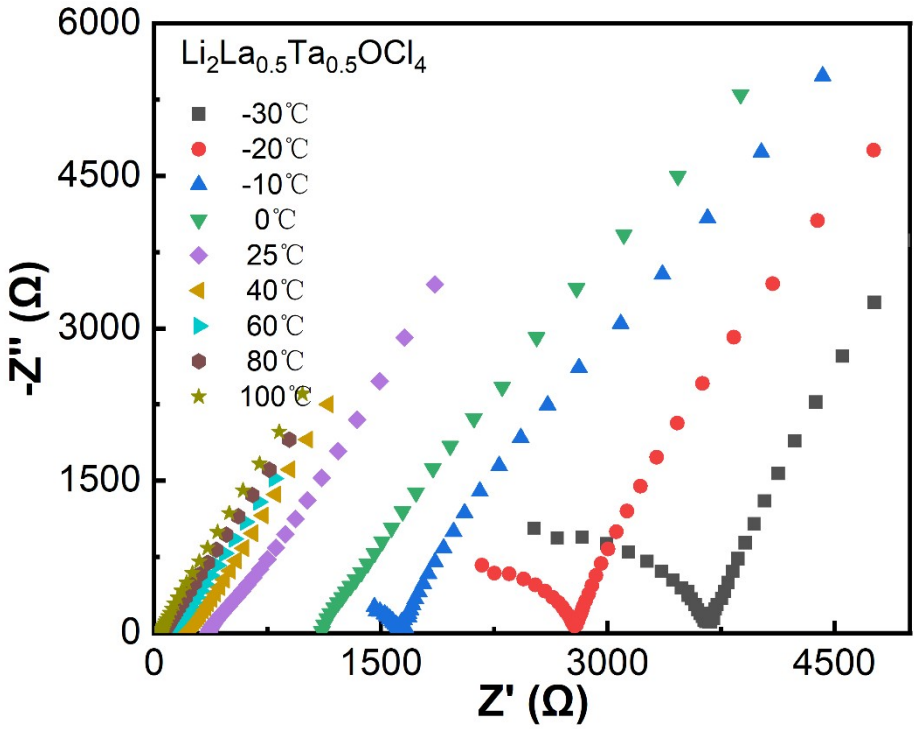

Fig. S4 Nyquist profiles for $Li_2La_{0.5}Ta_{0.5}OCl_4$ in the temperature range of -30 ºC and 100 °C.

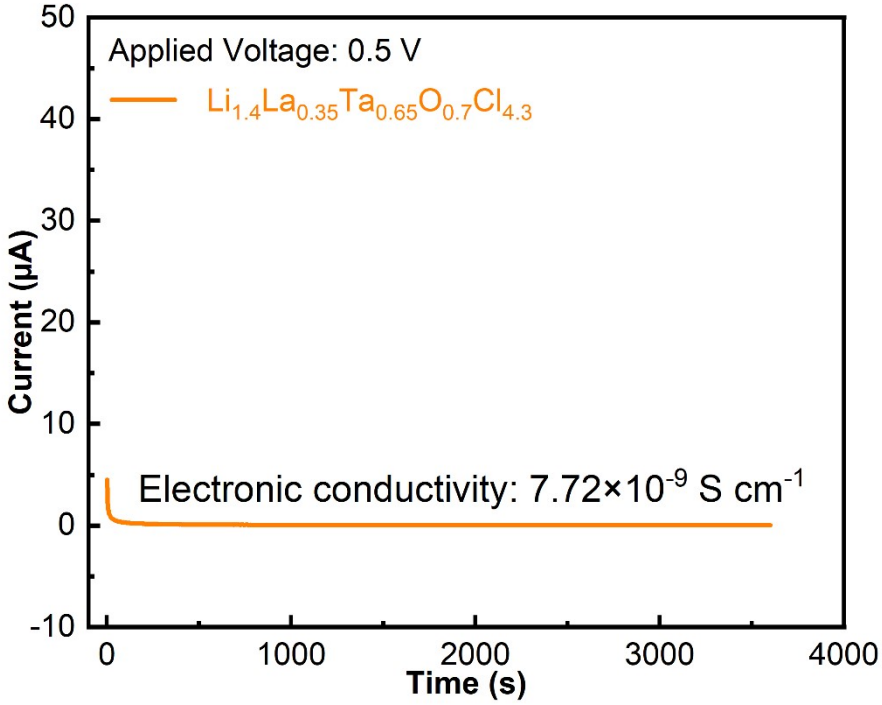

Fig. S5 Direct-current polarization curve for $Li_{1.4}La_{0.35}Ta_{0.65}O_{0.7}Cl_{4.3}$.

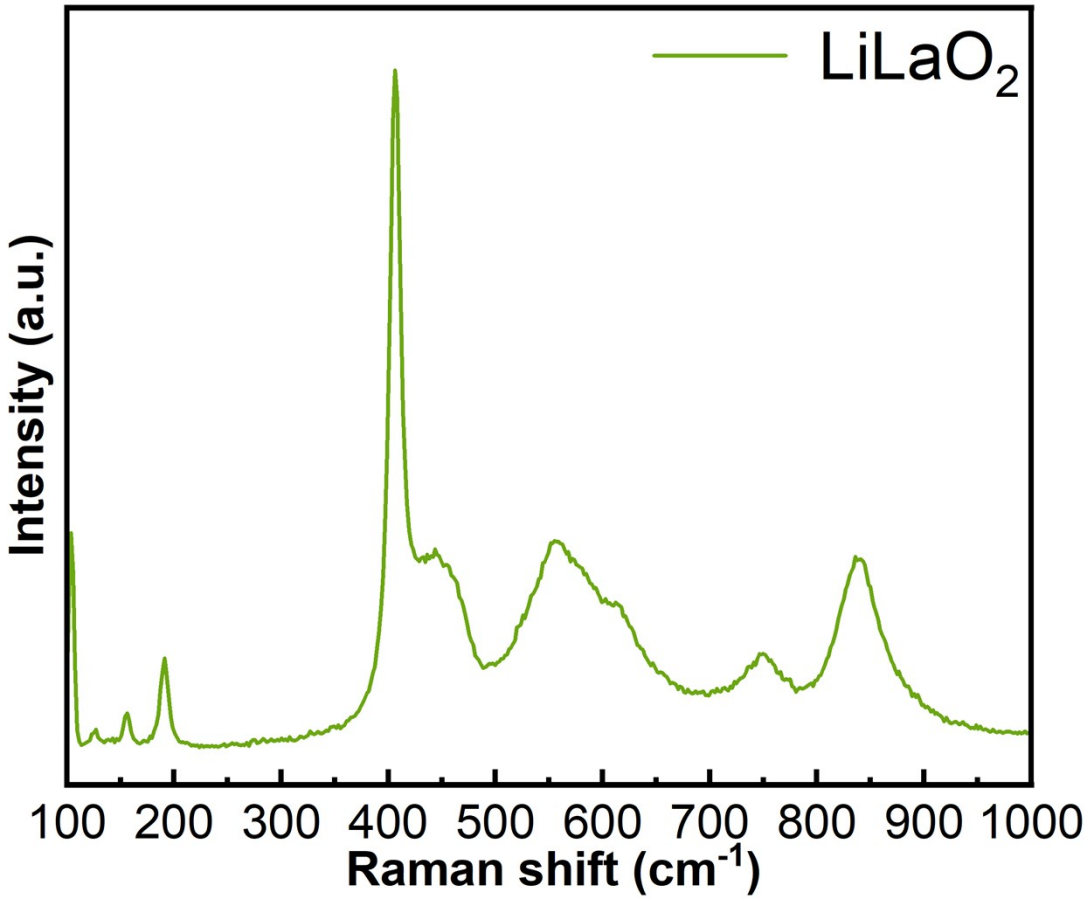

Fig. S6 Raman spectrum of as-prepared $LiLaO_2$.

Table S1. Comparison of ionic conductivities and symmetric Li cells with the representative halide SEs

Materials	**Conductivity (mS cm^{-1})**	**Critical current density (mA cm^{-2})**	**Galvanostatic cycling: current density (mA cm^{-2}), fixed capacity (mAh cm^{-2}), duration (h)**	**Overpotential (mV)**	**Ref.**
Li_3YCl_6	0.345	none	0.13, 0.13, 500	600	1
Li_3InCl_6	1.29	none	0.05, 0.05, 10 (at 80 ^{o}C)	surpassing 500	2
$Li_2OHCl/Li_3InCl_6/Li_2OHCl$	0.027	none	0.2, 0.2, 100 (at 80 ^{o}C)	approaching 500	
$Li_3YBr_{5.7}F_{0.3}$	1.8	0.9	0.1, 0.1, 1000	~50	3
Li_3YBr_6	2.1	0.3	0.1, 0.1, ~300	~100	
Li_3ScCl_6	3.0	none	0.1, 0.083, 2500	620	4

Li_2ZrCl_6	0.28	0.6	0.1, 0.025, ~300	~2000	5
$Li_2ZrCl_{5.5}F_{0.5}$	0.16	0.7	0.1, 0.025, 800	~1000	
Li_4YI_7	1.04	none	0.1, 0.1, 1000	12	6
$Li_{1.8}Fe_{1.1}Cl_4$	0.042	0.5	0.05, 0.05, 1600	approaching 2000	7
LiAlOCl-681	1.0	none	none	none	8
AlOCl	1.02	none	none	none	9
Li_2O-Li_2ZrCl_6	1.1	none	none	none	10
$Li_{0.388}Ta_{0.238}La_{0.475}Cl_3$	3.02	4	0.2, 1.0, 5000	~100	11
$Li_{1.4}La_{0.35}Ta_{0.65}O_{0.7}Cl_{4.3}$	4.9	40	10, 10, 1214	430	This work

References

1 C. Wang, J. Liang, J. Luo, J. Liu, X. Li, F. Zhao, R. Li, H. Huang, S. Zhao, L. Zhang, J. Wang and X. Sun, *Sci. Adv*., 2021, **7**, eabh1896.

2 Z. Deng, Z. Jin, D. Chen, D. Ni, M. Tian, Y. Zhan, S. Li, Y. Sun, X. Huang and Y. Zhao, *ACS Appl. Mater. Inter*., 2022, **14**, 48619-48626.

3 T. Yu, J. Liang, L. Luo, L. Wang, F. Zhao, G. Xu, X. Bai, R. Yang, S. Zhao, J. Wang, J. Yu and X. Sun, *Adv. Energy Mater*., 2021, **11**, 2101915.

4 J. Liang, X. Li, S. Wang, K. R. Adair, W. Li, Y. Zhao, C. Wang, Y. Hu, L. Zhang, S. Zhao, S. Lu, H. Huang, R. Li, Y. Mo and X. Sun, *J. Am. Chem. Soc*., 2020, **142**, 7012-7022.

5 P. Ganesan, M. Soans, M. A. Cambaz, R. Zimmermanns, R. Gond, S. Fuchs, Y. Hu, S. Baumgart, M. Sotoudeh, D. Stepien, H. Stein, A. Gross, D. Bresser, A. Varzi and M. Fichtner, *ACS Appl. Mater. Inter*., 2023, **15**, 38391-38402.

6 S. Zhang, F. Zhao, H. Su, Y. Zhong, J. Liang, J. Chen, M. Zheng, J. Liu, L.-Y. Chang, J. Fu, S. H. Alahakoon, Y. Hu, Y. Liu, Y. Huang, J. Tu, T. K. Sham and X. Sun, *Angew. Chem. Int. Ed*., 2024, **63**, e202316360.

7 F. Sun, Z. Gao, Y. Yang, H. Chen and H. Chen, *ACS Appl. Mater. Inter*., 2024, **16**, 55666-55674.

8 G. Wang, S. Zhang, H. Wu, M. Zheng, C. Zhao, J. Liang, L. Zhou, J. Yue, X. Zhu, Y. Xu, N. Zhang, T. Pang, J. Fu, W. Li, Y. Xia, W. Yin, X. Sun and X. Li, *Adv. Mater*., 2024, **36**, 2410402.

9 H. Duan, C. Wang, X.-S. Zhang, J. Fu, W. Li, J. Wan, R. Yu, M. Fan, F. Ren, S. Wang, M. Zheng, X. Li, J. Liang, R. Wen, S. Xin, Y.-G. Guo and X. Sun, *J. Am. Chem. Soc*., 2024, **146**, 29335-29343.

10 H. Kwak, J. S. Kim, D. Han, J. S. Kim, J. Park, G. Kwon, S.-M. Bak, U. Heo, C. Park, H. W. Lee, K. W. Nam, D. H. Seo and Y. S. Jung, *Nat. Commun*., 2023, **14**, 2459.

11 Y. C. Yin, J. T. Yang, J. D. Luo, G. X. Lu, Z. Huang, J. P. Wang, P. Li, F. Li, Y.-C. Wu, T. Tian, Y. F. Meng, H. S. Mo, Y. H. Song, J. N. Yang, L. Z. Feng, T. Ma, W. Wen, K. Gong, L. J. Wang, H. X. Ju, Y. Xiao, Z. Li, X. Tao and H.-B. Yao, *Nature*, 2023, **616**, 77-83.