<u>**Supplementary information**</u>

Experimental and computational investigation on the charge storage performance of a novel Al_2O_3-grpahene hybrid electrode

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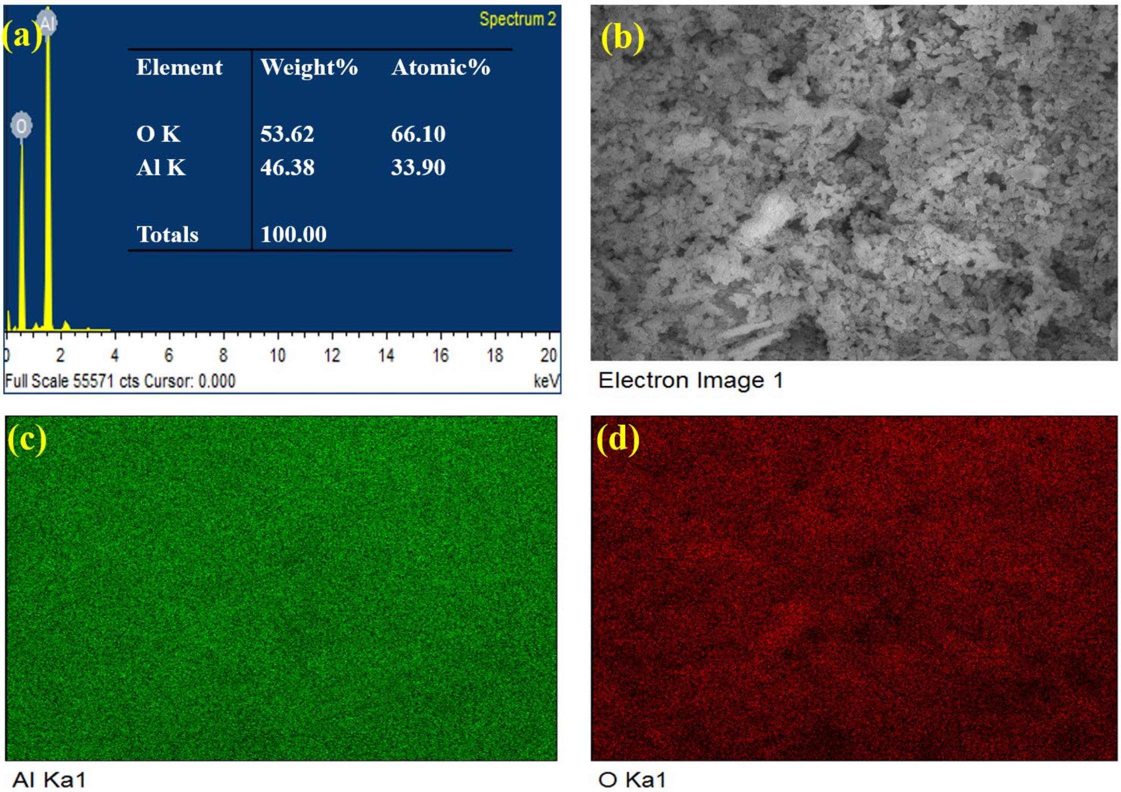

Figure S1. (a) The EDX spectrum Al_2O_3, (b) FE-SEM micrograph for elemental mapping of Al_2O_3, (c) aluminium and (d) oxygen.

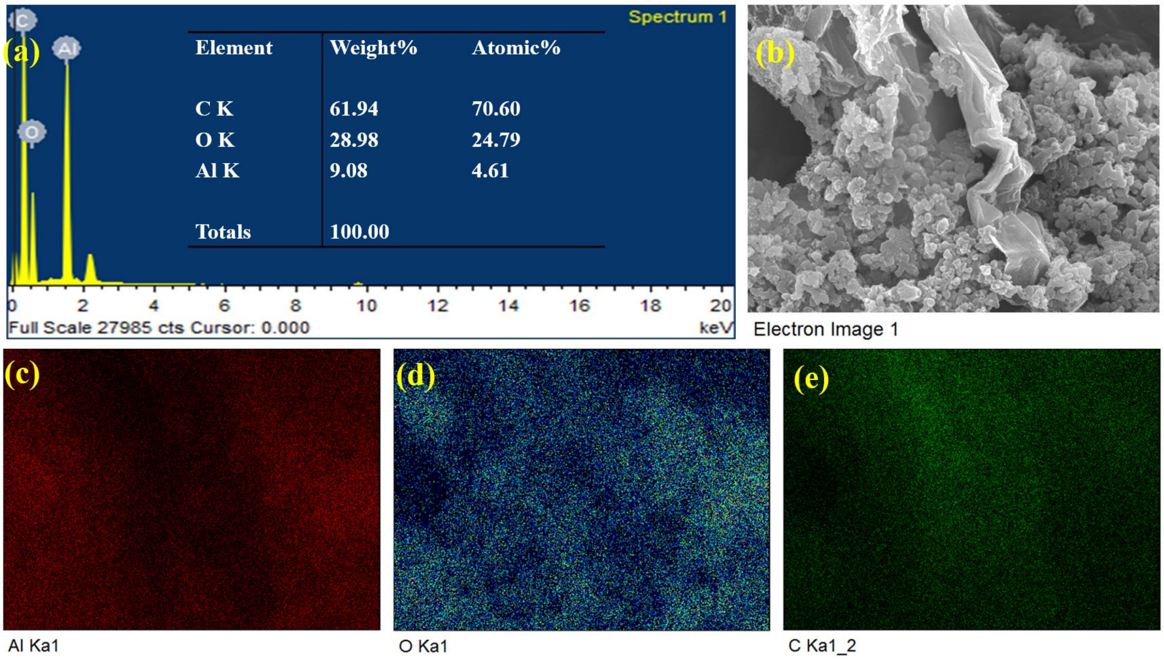

Figure S2. (a) The EDX spectrum Al_2O_3-graphene hybrid, (b) FE-SEM micrograph for elemental mapping of Al_2O_3-graphene hybrid, (c) aluminium, (d) oxygen and (e) carbon.

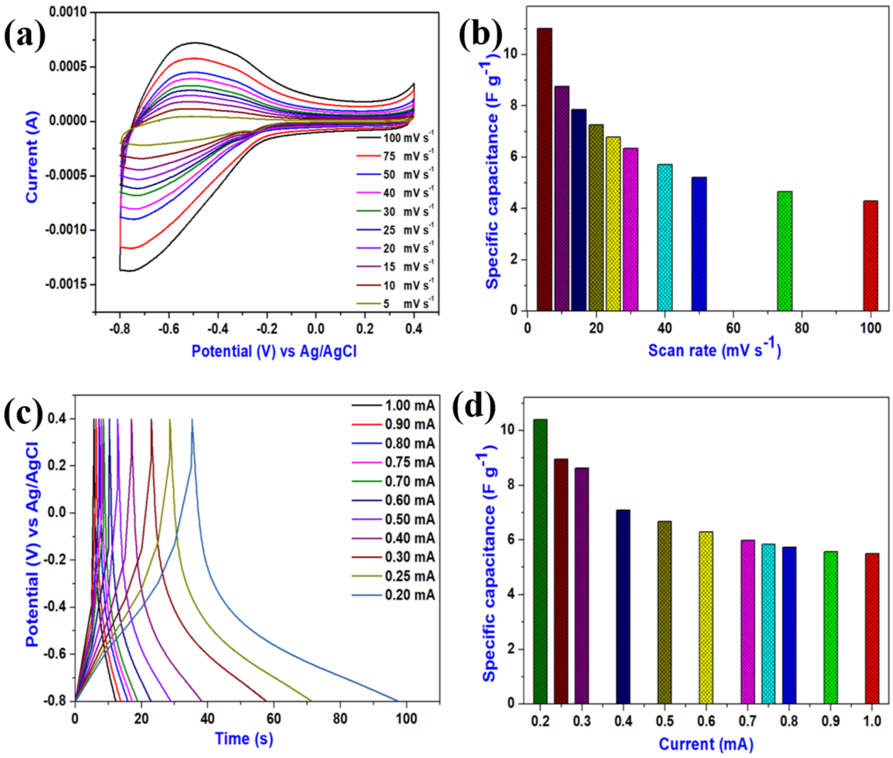

Figure S3. Electrochemical characterization of Al_2O_3 electrode. (a) Cyclic voltammetric profiles of Al_2O_3 electrode at various scan rates 5-100 mV s^{-1}, (b) effect of scan rates on specific capacitances of Al_2O_3 electrode, (c) charge-discharge profile of Al_2O_3 electrode at various applied currents and (d) effect of applied currents on specific capacitances of Al_2O_3 electrode.

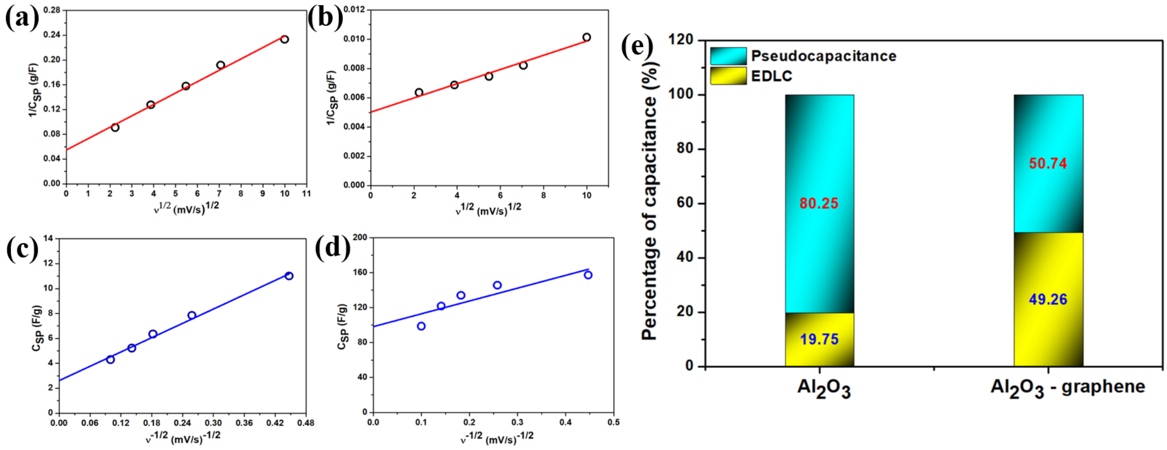

Figure S4. Trasatti plot for Al_2O_3 and Al_2O_3-graphene hybrid. Dependence of 1 / Csp on $v^{1/2}$ for (a) Al_2O_3 electrode and (b) Al_2O_3-graphene hybrid electrode. Dependence of Csp on $v^{-1/2}$ for (c) Al_2O_3 electrode and (d) Al_2O_3-graphene hybrid electrode in Na_2SO_4 electrolyte. (e) The contribution of EDLC and pseudocapacitance of Al_2O_3 electrode and Al_2O_3-graphene hybrid electrode.

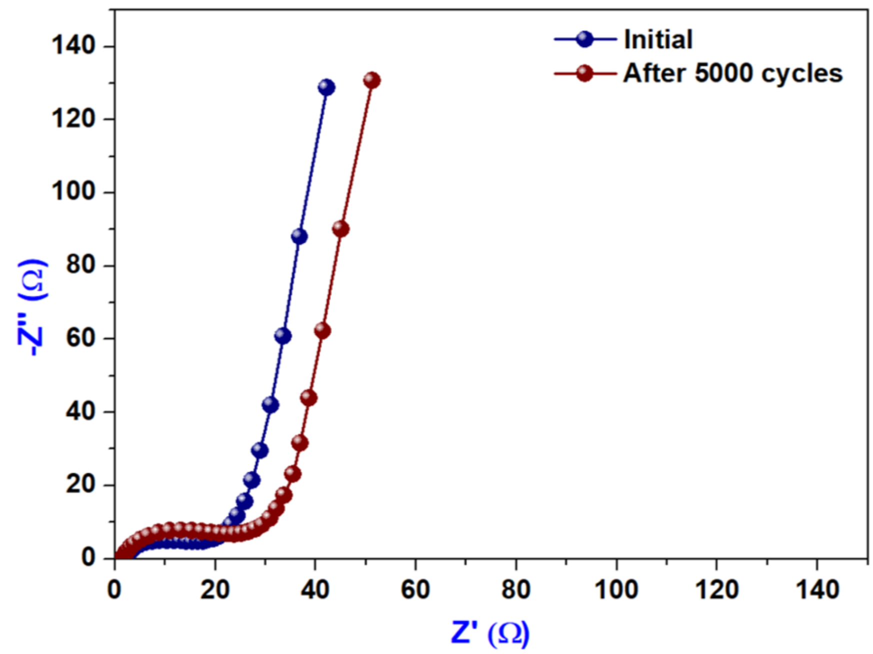

Figure S5. The comparative Nyquist plot for Al_2O_3-graphene hybrid electrode at initial and after cyclic stability test.

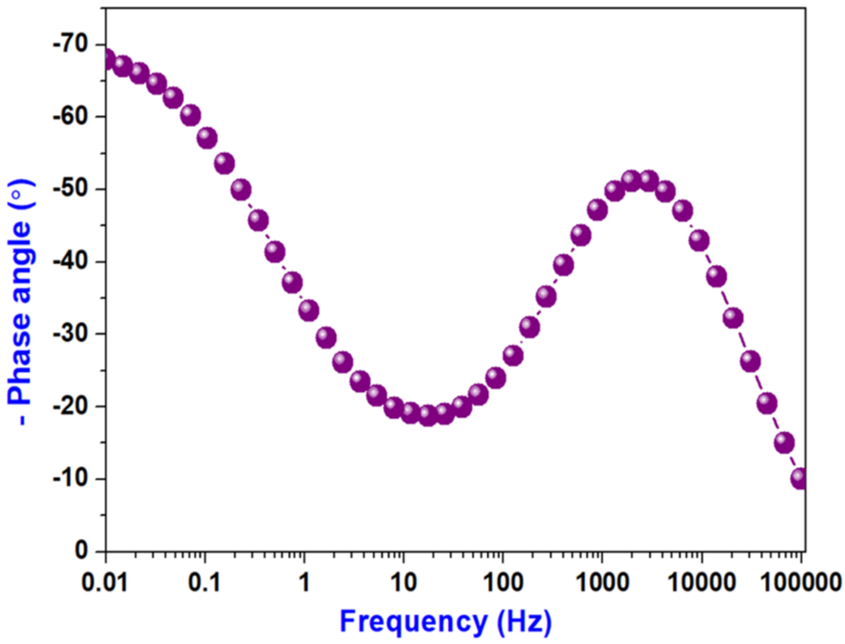

Figure S6. Bode phase angle plot of Al_2O_3-graphene hybrid//Al_2O_3-graphene hybrid SSD.

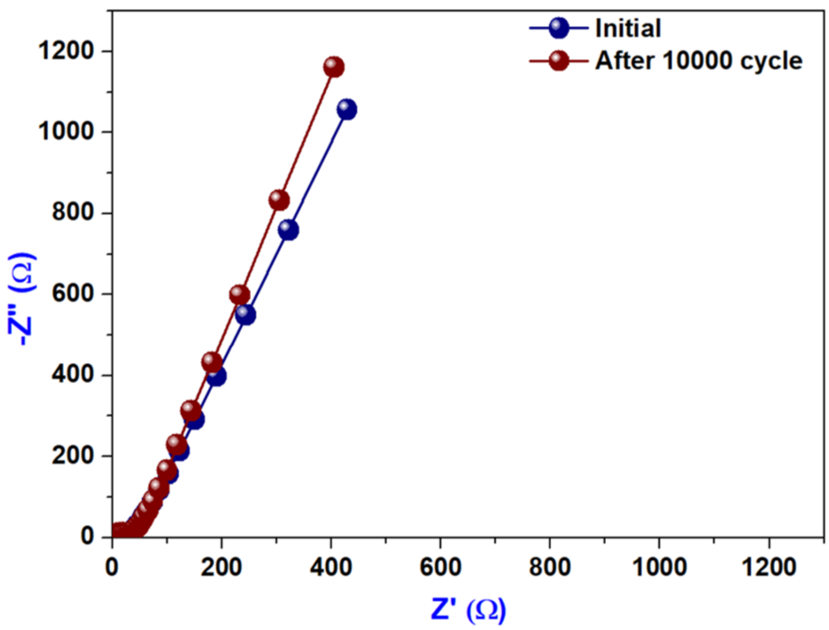

Figure S7. The comparative Nyquist plot for Al_2O_3-graphene hybrid//Al_2O_3-graphene hybrid SSD at initial and after cyclic stability test.

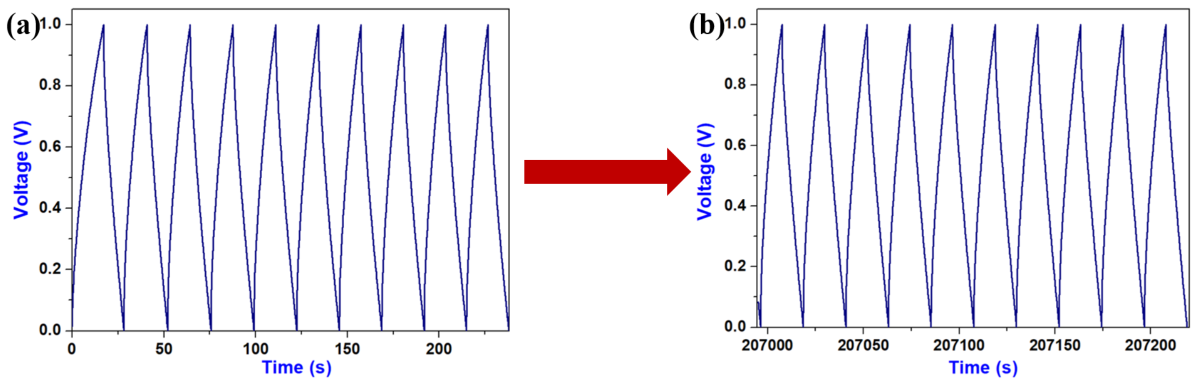

Figure S8. The initial and final ten cycles of Al_2O_3-graphene hybrid//Al_2O_3-graphene hybrid SSD in cyclic stability test.

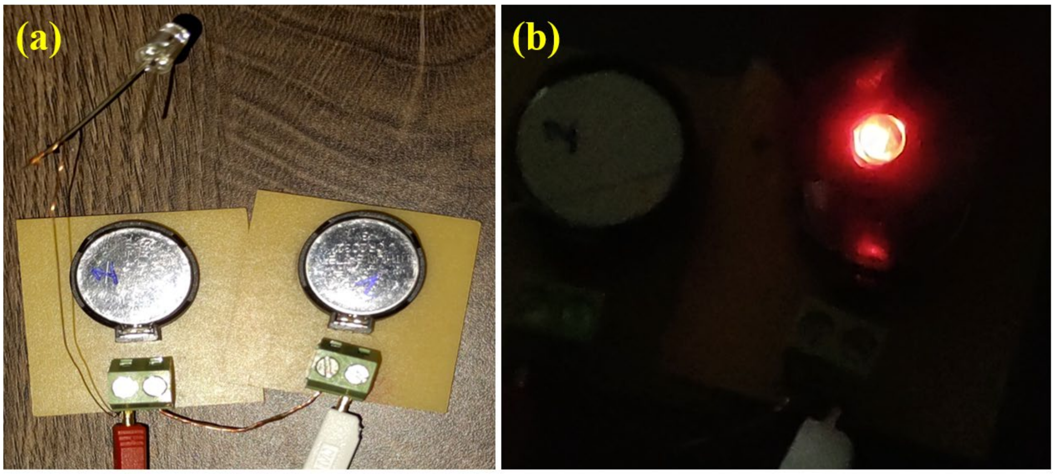

Figure S9. The practical application of Al_2O_3-graphene hybrid//Al_2O_3-graphene hybrid SSD in series connection of two-coin cells (a) without glowing an LED, (b) glowing a red LED by fully charged Al_2O_3-graphene hybrid//Al_2O_3-graphene hybrid SSD in series connection of two-coin cells.

Table S1. Summary of supercapacitive performances of Al_2O_3-graphene hybrid electrode and reported supercapacitor electrode materials using three-electrode system.

Material	Preparation method	Specific capacitance (F g^{-1})	Reference
$CuSbS_2$	Colloidal method	22	[1]
$CuSbSe_2$	Colloidal	48	[1]
Cu_3SbS_4	Hydrothermal	60	[2]
$FeMoO_4$ /Graphene	Hydrothermal	135	[3]
Cu_2MoS_4	Hydrothermal	135.78	[4]
ZnS	Solvothermal	32.8	[5]
WS_2	Chemical exfoliation	40	[6]
CuO	Wet chemical method	88.5	[7]
RuO_2	Chemical synthesis	50	[8]
MoO_3	Solution combustion method	108.88	[9]
MoS_2	Hydrothermal	92.85	[10]
Al_2O_3-graphene	**Hydrothermal**	**157.29**	**This work**

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