

Supporting Information

Graphite–Metal Composite Electrode with Tunable Work Function for Use in Optoelectronic Devices

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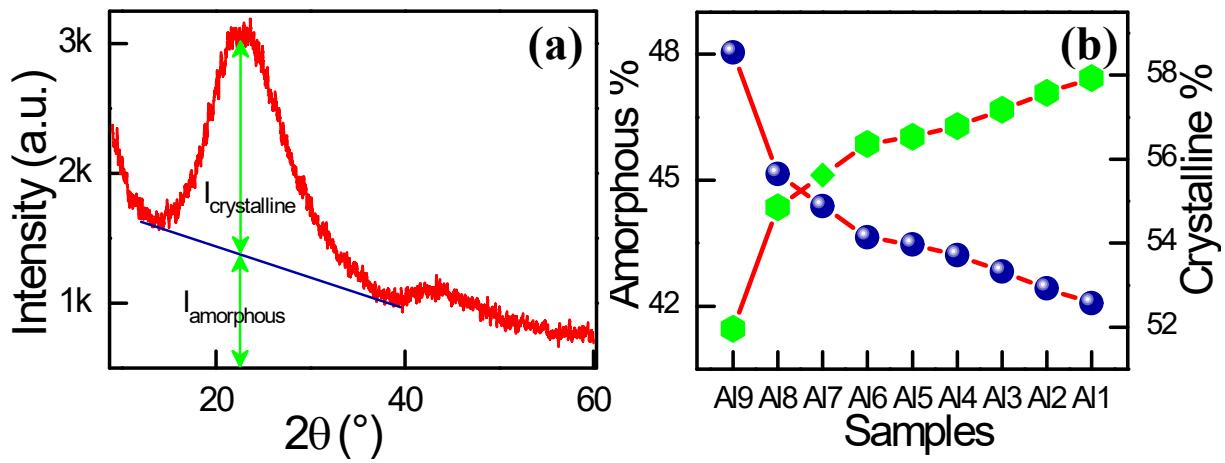


Fig. S1. (a) Graphical representation of the estimated crystalline and amorphous regions and (4)] and (b) crystalline and amorphous percentages of G:Al composite electrodes.

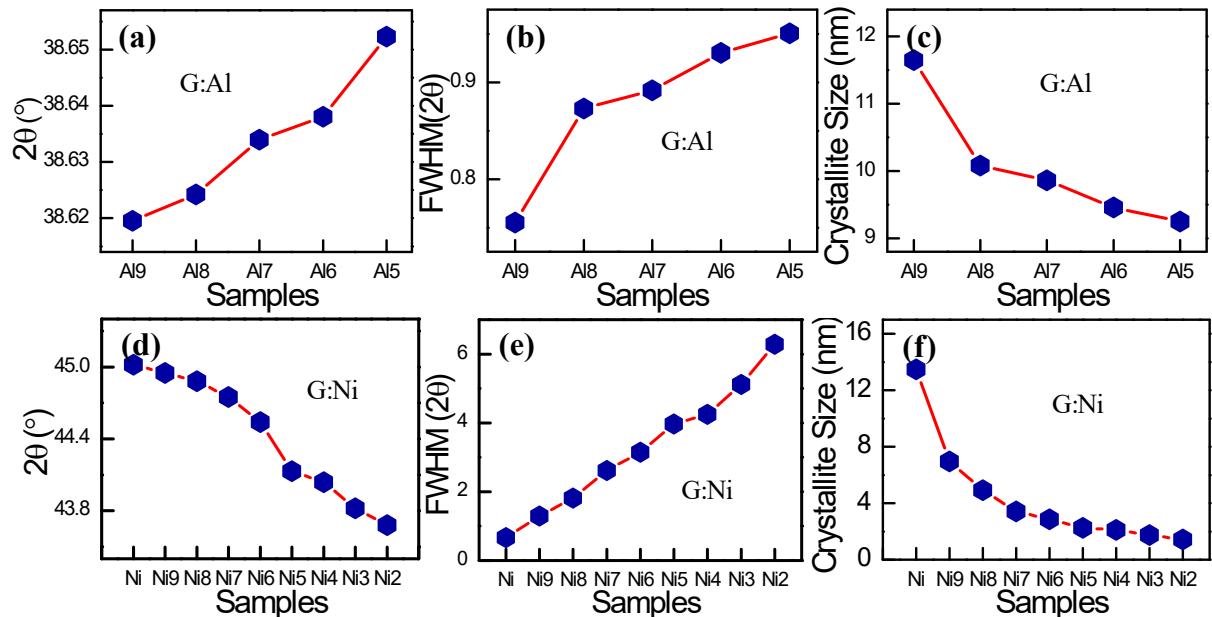


Fig. S2. Variation in 2θ peaks of (a) G:Al and (d) G:Ni composite electrodes. Variation in the full-width at half maximum (FWHM, 2θ) for (b) G:Al and (e) G:Ni electrodes. Variation in the crystallite size for (c) G:Al and (f) G:Ni electrodes.

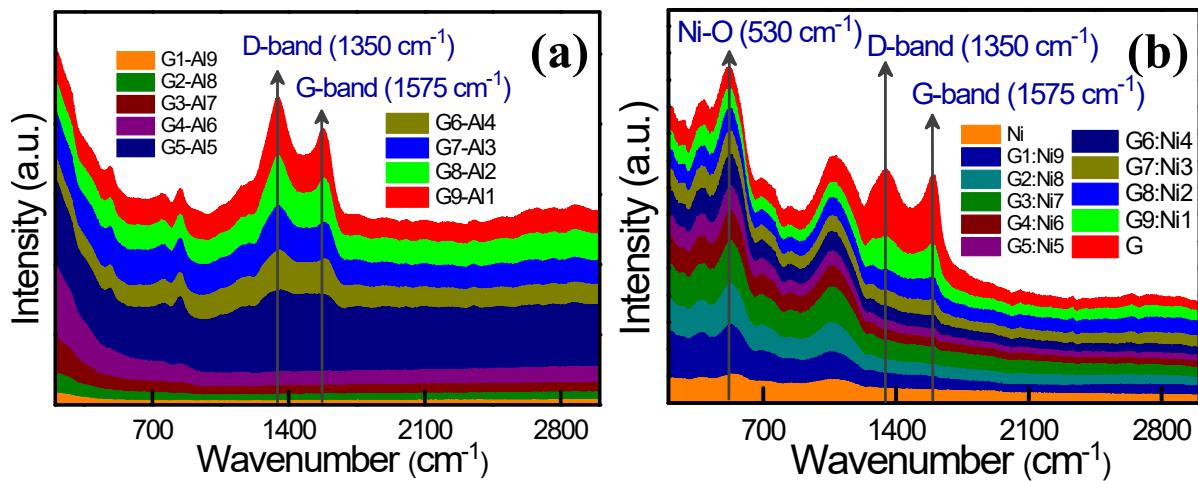


Fig. S3. Raman spectra of (a) G:Al and (b) G:Ni composite electrodes.

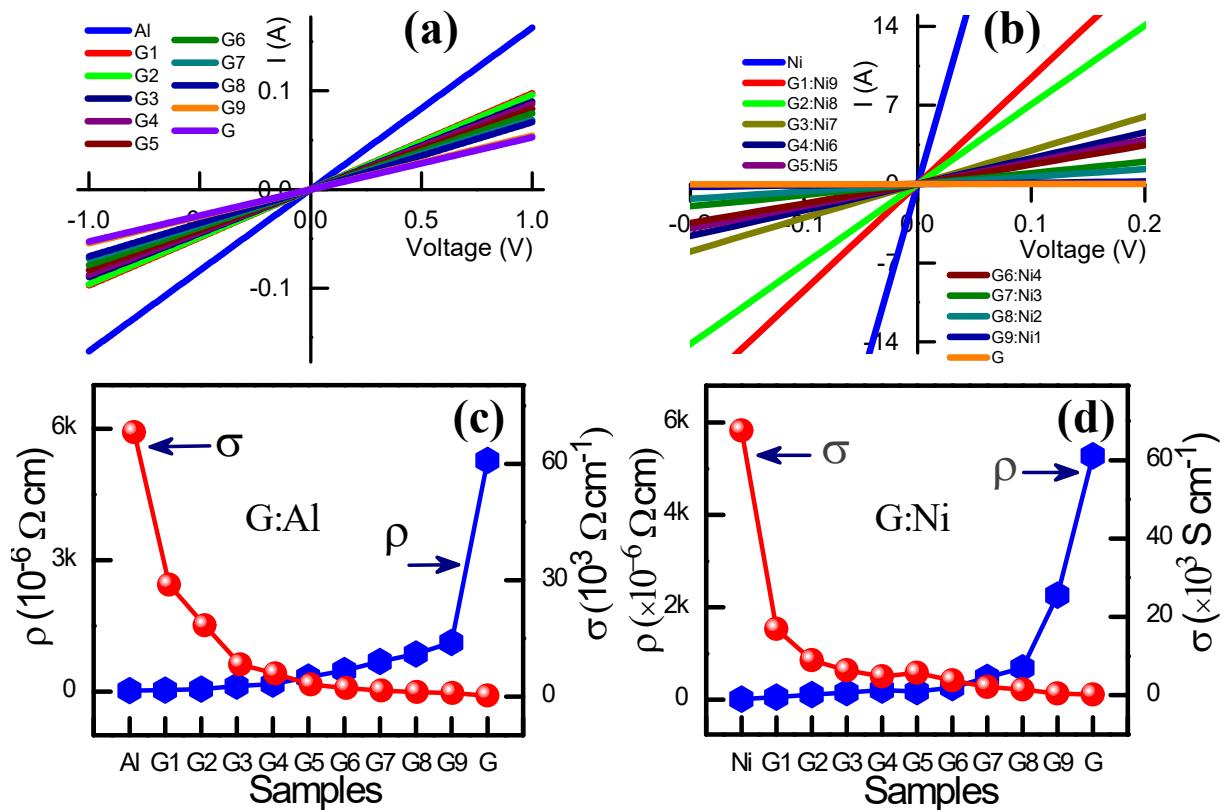


Fig. S4. Current–voltage characteristics of (a) G:Al and (b) G:Ni composite electrodes. Conductivity of (c) G:Al and (d) G:Ni composite electrodes.

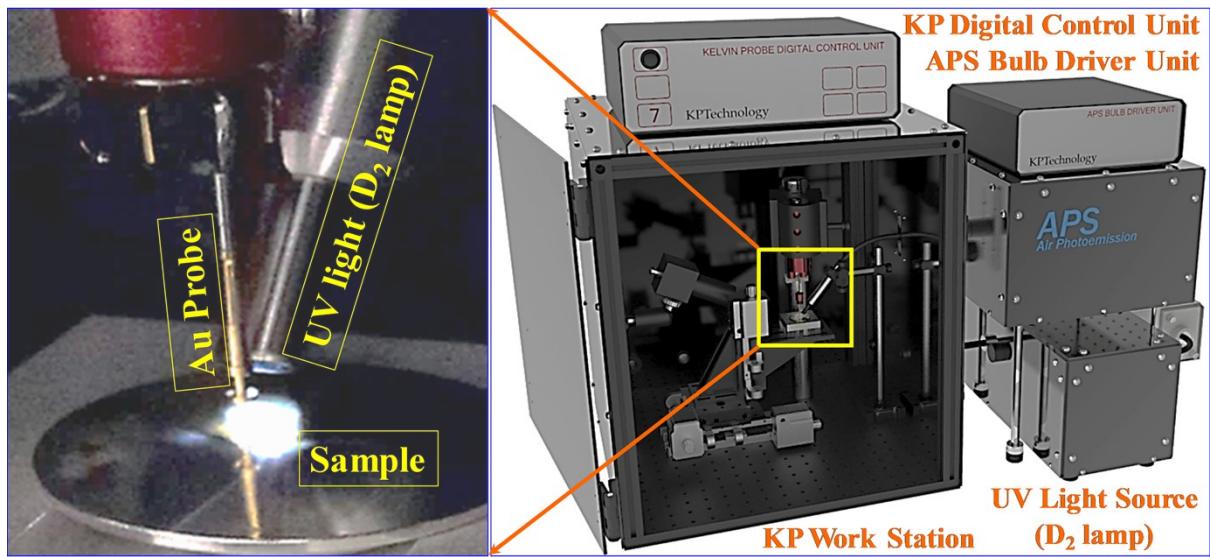


Fig. S5. Setup for atmospheric pressure photoemission spectroscopy (APS).

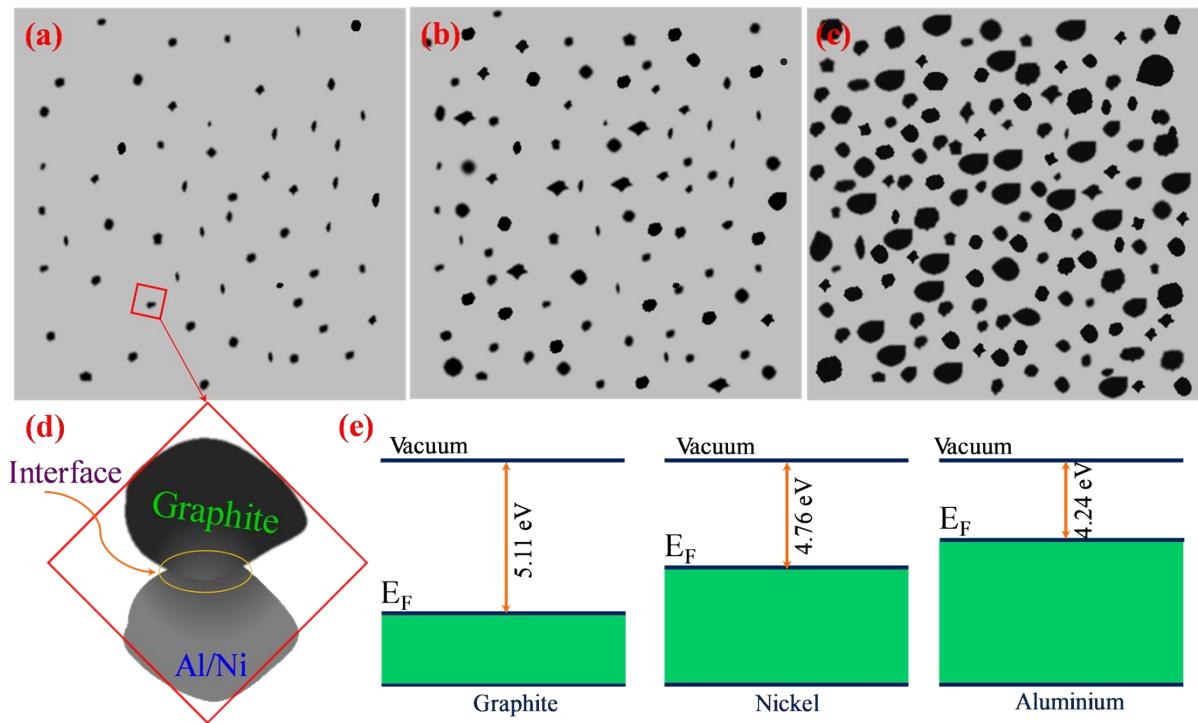


Fig. S6. Distribution of graphite in G:Al/G:Ni hybrid electrode systems with (a) low, (b) medium, and (c) high graphite content; (d) schematic of G/Al or G/Ni hybrid electrode interface; and (e) energy band structures with work function representation of graphite, Ni, and Al (from left to right).

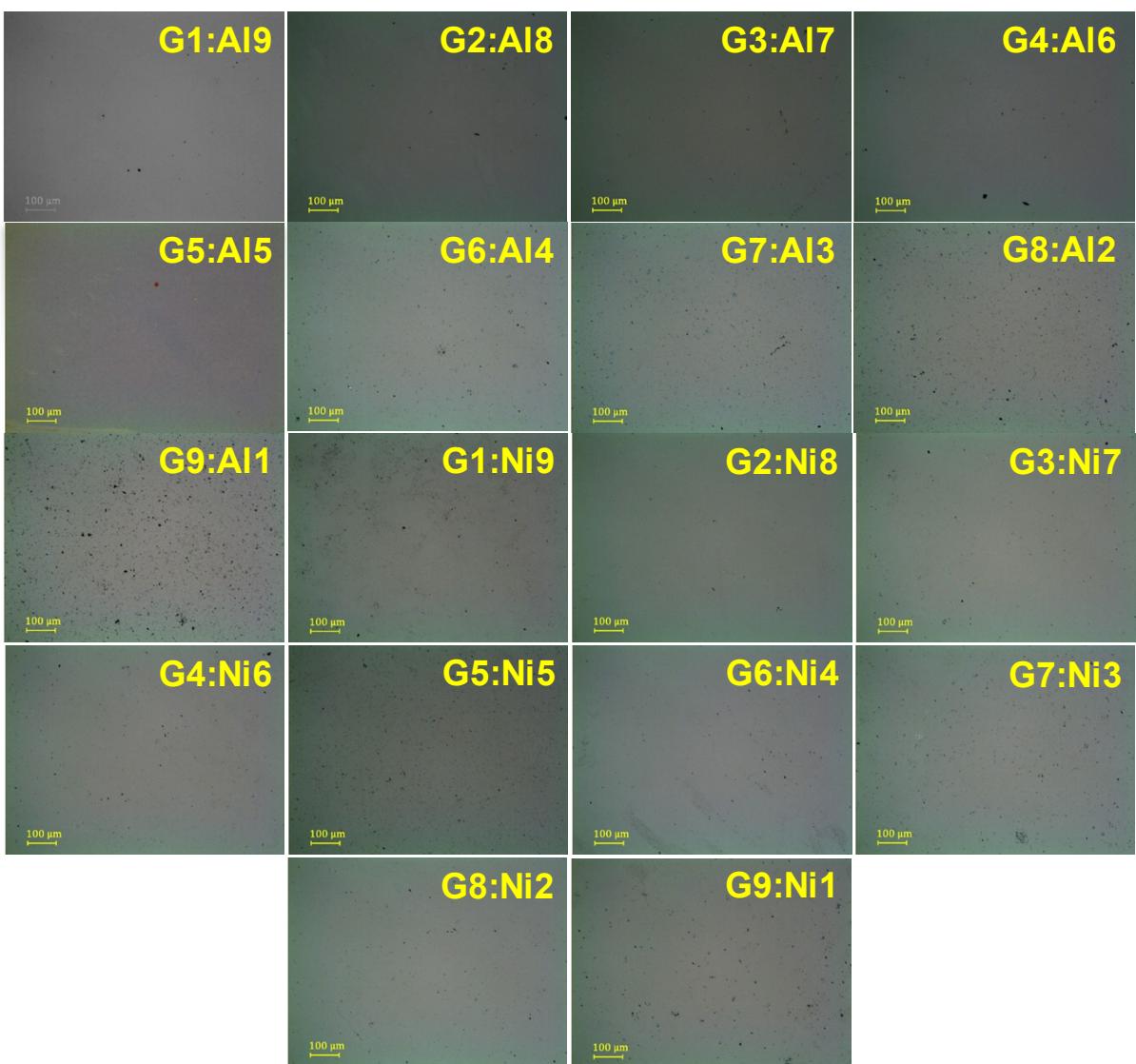


Fig. S7. G:Al and G:Ni optical micrograph images (5X magnification). The scale bar is 100 μm .

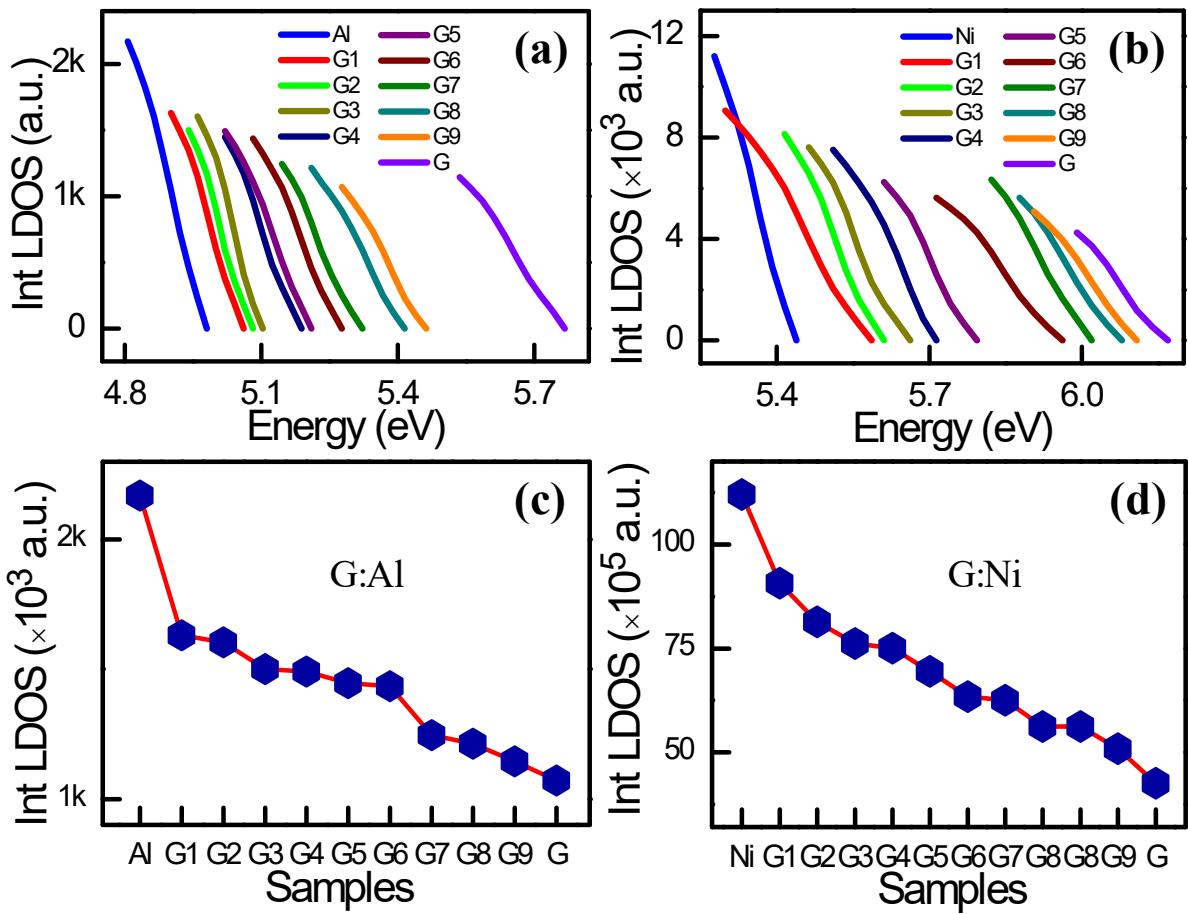


Fig. S8. Variation in the integrated local density of states (LDOS) with the energy for (a) G:Al and (b) G:Ni composite electrodes. Composition-dependent LDOS variation for (c) G:Al and (d) G:Ni composite electrodes.

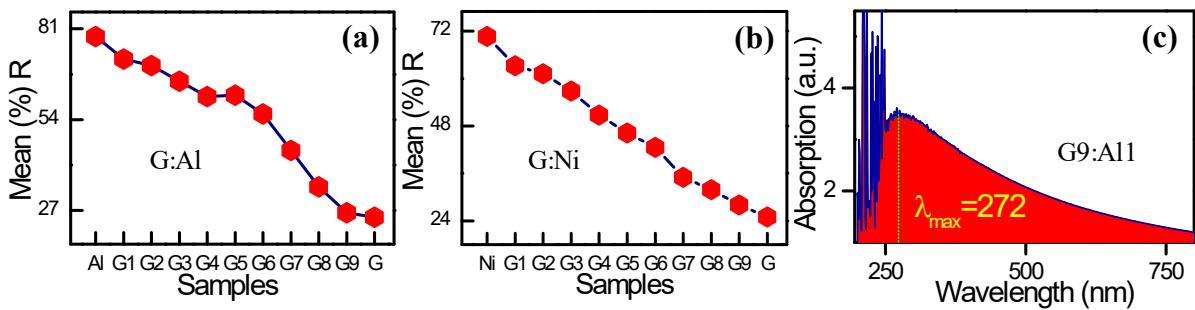


Fig. S9. Composition-dependent variation in the optical reflectance percentages of (a) G:Al and (b) G:Ni composite electrodes. (c) Optical absorption spectrum of G9:Al1 composite electrodes.

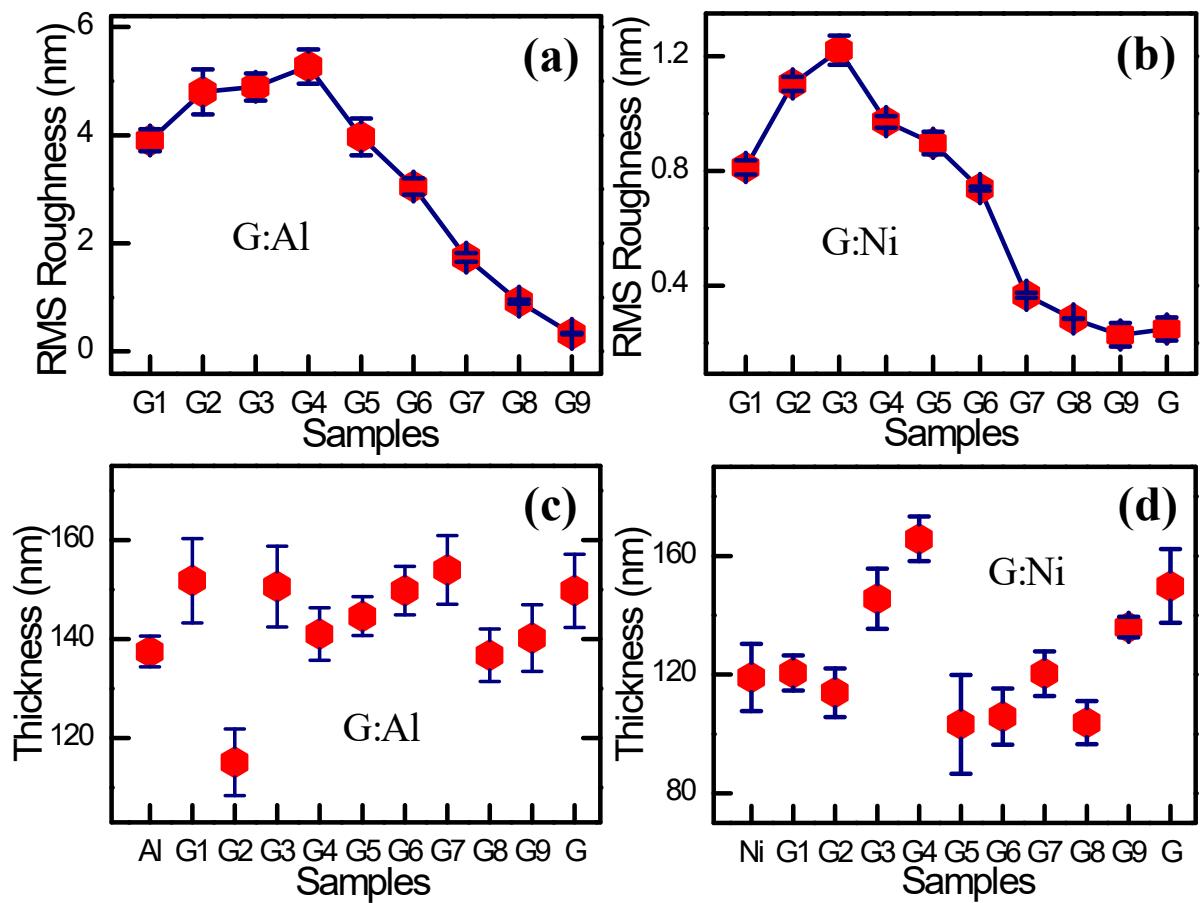


Fig. S10. Root mean square roughness of (a) G:Al and (b) G:Ni composite electrodes. Thickness of (c) G:Al and (d) G:Ni composite electrodes.

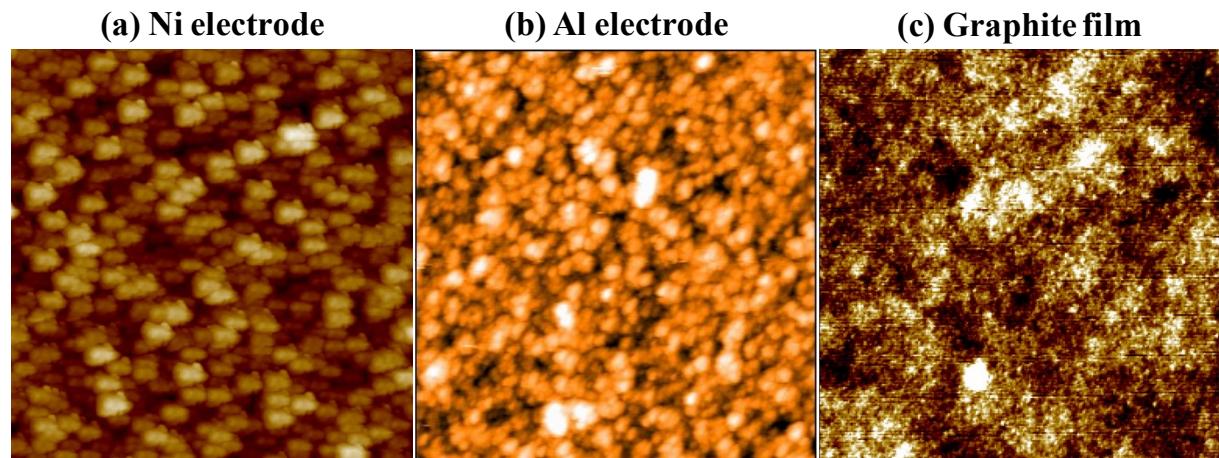


Fig. S11. AFM images of (a) Ni electrode, (b) Al electrode, and (c) graphite film, respectively.

Table S1. Electrical, optical and morphological parameters of G:Al composite electrodes.

Sample	Rs ($\Omega \text{ sq}^{-1}$)	$\rho (10^{-6})$ $\Omega \text{ cm}$	$\sigma (10^3)$ $\Omega \text{ cm}^{-1}$	WF (eV)	CPD (eV)	Roughness (nm)	Thickness (nm)	Mean %R
Al	1.067 \pm 0.01	14.672	68.157	4.245 \pm 0.047	Ref	3.11 \pm 0.21	137.5 \pm 3.2	78.73
G1:Al9	2.284 \pm 0.03	34.669	28.844	4.353 \pm 0.031	0.108	3.91 \pm 0.21	151.8 \pm 8.5	72.05
G2:Al8	4.737 \pm 0.03	54.537	18.337	4.421 \pm 0.037	0.206	4.79 \pm 0.42	115.2 \pm 6.7	70.07
G3:Al7	8.061 \pm 0.11	121.396	8.238	4.478 \pm 0.055	0.234	4.89 \pm 0.25	150.6 \pm 8.2	65.41
G4:Al6	11.906 \pm 0.06	167.875	5.957	4.499 \pm 0.117	0.255	5.27 \pm 0.32	141.1 \pm 5.3	61.25
G5:Al5	22.552 \pm 0.05	326.221	3.065	4.519 \pm 0.081	0.275	3.96 \pm 0.34	144.7 \pm 3.9	60.86
G6:Al4	31.913 \pm 2.07	478.049	2.092	4.558 \pm 0.028	0.313	3.05 \pm 0.15	149.8 \pm 4.9	55.66
G7:Al3	44.188 \pm 0.49	680.488	1.469	4.636 \pm 0.033	0.392	1.74 \pm 0.09	154.1 \pm 6.9	44.89
G8:Al2	62.789 \pm 0.42	858.642	1.165	4.785 \pm 0.041	0.541	0.93 \pm 0.04	136.8 \pm 5.4	34.01
G9:Al1	80.052 \pm 9.11	1122.726	0.891	5.019 \pm 0.061	0.775	0.34 \pm 0.02	140.2 \pm 6.8	26.32
Graphite	352.2 \pm 4.64	5275.956	0.189	5.111 \pm 0.031	0.866	0.259 \pm 0.04	149.8 \pm 7.4	24.96

Table S2. Electrical, optical and morphological parameters of G:Ni composite electrodes.

Sample	Rs ($\Omega \text{ sq}^{-1}$)	$\rho (10^{-6})$ $\Omega \text{ cm}$	$\sigma (10^3)$ $\Omega \text{ cm}^{-1}$	WF (eV)	CPD (eV)	Roughness (nm)	Thickness (nm)	Mean %R
Ni	1.244 \pm 0.005	14.812	67.513	4.673 \pm 0.039	Ref	0.971 \pm 0.027	119.1 \pm 11	70.66
G1:Ni9	4.903 \pm 0.043	59.102	16.919	4.704 \pm 0.072	0.031	0.812 \pm 0.024	120.6 \pm 06	63.24
G2:Ni8	9.762 \pm 0.061	111.171	8.995	4.729 \pm 0.018	0.056	1.104 \pm 0.025	113.9 \pm 08	61.23
G3:Ni7	10.765 \pm 0.045	156.728	6.381	4.749 \pm 0.046	0.076	1.223 \pm 0.051	145.6 \pm 10	56.87
G4:Ni6	12.533 \pm 0.036	207.647	4.816	4.761 \pm 0.077	0.088	0.973 \pm 0.019	165.7 \pm 08	50.78
G5:Ni5	16.825 \pm 0.028	173.655	5.759	4.782 \pm 0.059	0.108	0.898 \pm 0.039	103.2 \pm 16	46.21
G6:Ni4	24.645 \pm 0.141	260.793	3.835	4.808 \pm 0.064	0.135	0.739 \pm 0.007	105.8 \pm 10	42.58
G7:Ni3	40.417 \pm 0.093	486.411	2.056	4.921 \pm 0.084	0.248	0.367 \pm 0.001	120.4 \pm 08	35.06
G8:Ni2	66.231 \pm 0.187	681.302	1.455	4.931 \pm 0.034	0.258	0.286 \pm 0.007	103.8 \pm 07	31.91
G9:Ni1	166.3 \pm 4.101	2260.571	0.443	4.961 \pm 0.034	0.287	0.229 \pm 0.041	135.9 \pm 03	28.04
Graphite	352.2 \pm 4.642	5275.956	0.189	5.111 \pm 0.030	0.438	0.249 \pm 0.041	149.8 \pm 12	24.96

Table S3. X-ray diffraction structural parameters of G:Al composite electrodes.

Sample	$2\theta^\circ$ (111)	FWHM	Crystallite size (nm)	Interplanar distance 'd' (Å)	Lattice Constant 'a' (Å)
G1:Al9	38.6195	0.7553	11.65	2.3295	4.03484
G2:Al8	38.6242	0.8728	10.08	2.3292	4.03435
G3:Al7	38.6341	0.8918	9.86	2.3287	4.03337
G4:Al6	38.6381	0.9302	9.46	2.3285	4.03301
G5:Al5	38.6523	0.9507	9.25	2.3276	4.03154

Table S4. X-ray diffraction structural parameters of G:Ni composite electrodes.

Sample	$2\theta^\circ$ (111)	FWHM	Crystallite size (nm)	Interplanar distance 'd' (Å)	Lattice Constant 'a' (Å)
Ni	45.02	0.666	13.49	2.0121	3.48492
G1:Ni9	44.95	1.29	6.96	2.0151	3.49011
G2:Ni8	44.88	1.82	4.93	2.0181	3.49527
G3:Ni7	44.75	2.62	3.43	2.0236	3.50489
G4:Ni6	44.54	3.15	2.85	2.0326	3.52057
G5:Ni5	44.13	3.97	2.26	2.0505	3.55163
G6:Ni4	44.04	4.25	2.11	2.0545	3.55853
G7:Ni3	43.82	5.12	1.75	2.0643	3.57551
G8:Ni2	43.68	6.29	1.42	2.0706	3.58641

Table S5. Local density of states (LDOS) of G-Al and G-Ni composite electrodes.

Sample	LDOS x 10 ³ (au)	Sample	LDOS x 10 ³ (au)
Al	1937.06	Ni	1236.302
G1:Al9	1870.52	G1:Ni9	1187.103
G2:Al8	1628.51	G2:Ni8	1098.987
G3:Al7	1579.96	G3:Ni7	998.2143
G4:Al6	1278.71	G4:Ni6	965.9529
G5:Al5	1088.38	G5:Ni5	867.5658
G6:Al4	1081.28	G6:Ni4	821.2041
G7:Al3	992.898	G7:Ni3	805.5307
G8:Al2	854.344	G8:Ni2	799.6565
G9:Al1	837.524	G9:Ni1	735.9873
Graphite	697.491	Graphite	697.4911