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Supporting Information for

Formation of 3D graphene-Ni foam heterostructures with enhanced performance and durability for bipolar plates in a polymer electrolyte membrane fuel cell

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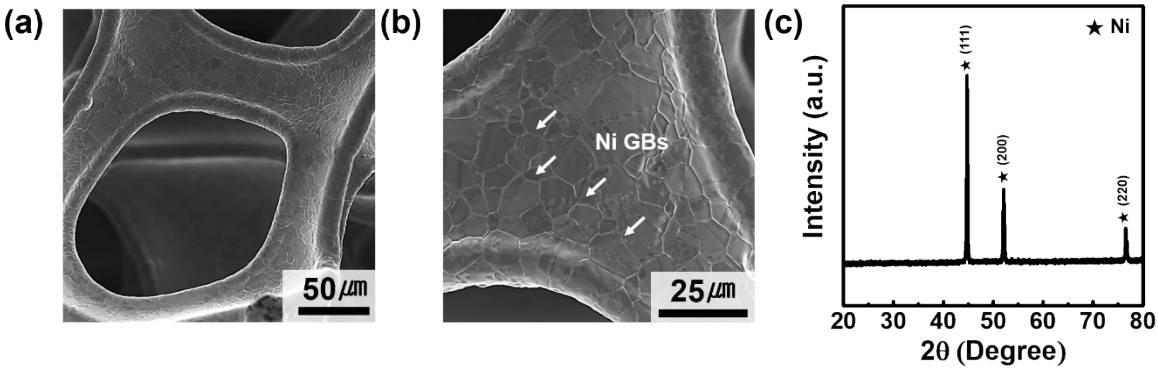

Fig. S1. (a-b) The representative SEM images of bare Ni foam. (c) XRD patterns for bare Ni foam.

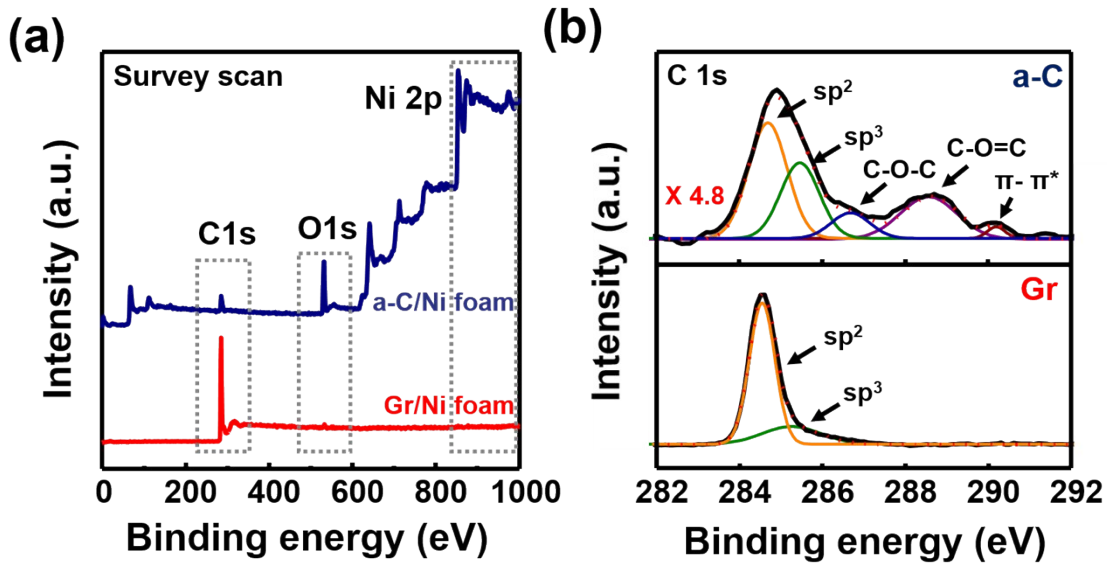

Fig. S2. Surface chemical analysis of a-C film and PMMA-derived graphene on Ni foam. (a) XPS wide-scan survey of a-C film (blue line) and graphene film (red line) on Ni foam. They are grown at 1000 °C for 3 min. Both graph show the dominant C 1*s* peak at the binding energy of 284.5 eV. Whereas, to the exclusion of the C 1*s* peak, other peaks originated from the Ni growth substrate (850-855 eV) and oxygenated group (528-540 eV) in spectrum of a-C film, they in the XPS spectra of graphene film were invisible due to thick graphene. (b) C 1*s* line-scan spectrum of a-C film (Top) and graphene film (bottom) on Ni foam. The C 1*s* line of a-C film can be deconvoluted into five peaks, corresponding to the sp^2 (284.5 eV), sp^3 (285.4 eV), C-O-C (286.5 eV), O-C=O (288.7 eV) and π-π* interaction (290.2 eV). In contrast, from the

C1s spectra of graphene film, we only found a dominant peak at 284.5 eV, which corresponds to the graphene sp^2 hybridized carbon.

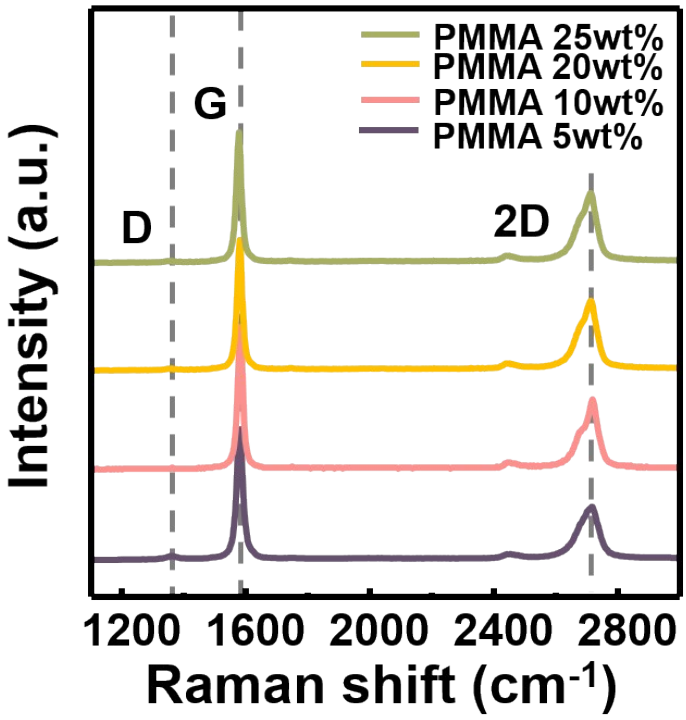

Fig. S3. The representative Raman spectra of as-grown samples at 1000 °C for 3 min as a function of the use of PMMA concentration.

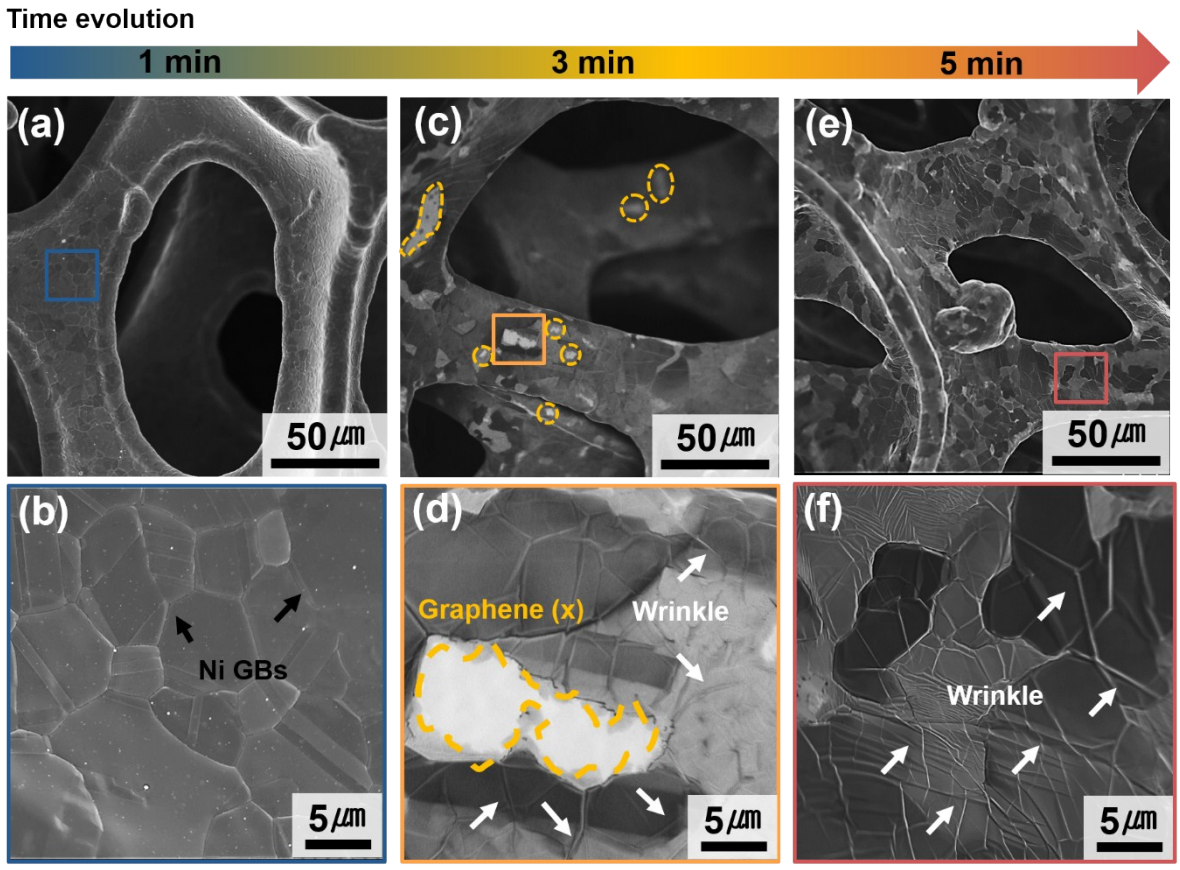

Fig. S4. Time evolution for the continuous, large-scale growth of graphene film on Ni foam. (a-f) Representative SEM images of graphene film on Ni foam grown at 1000 °C as a function of RTA time: (a-b) 1 min, (c-d) 3 min and (e-f) 5 min.

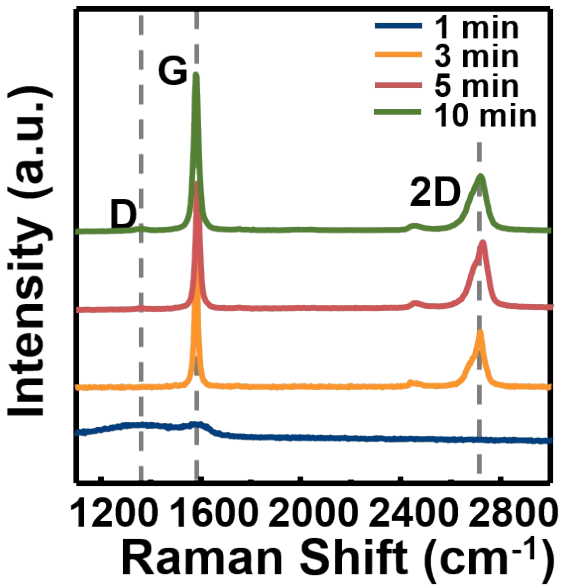

Fig. S5. Raman spectra of graphene films grown for times ranging from 1 to 10 min.

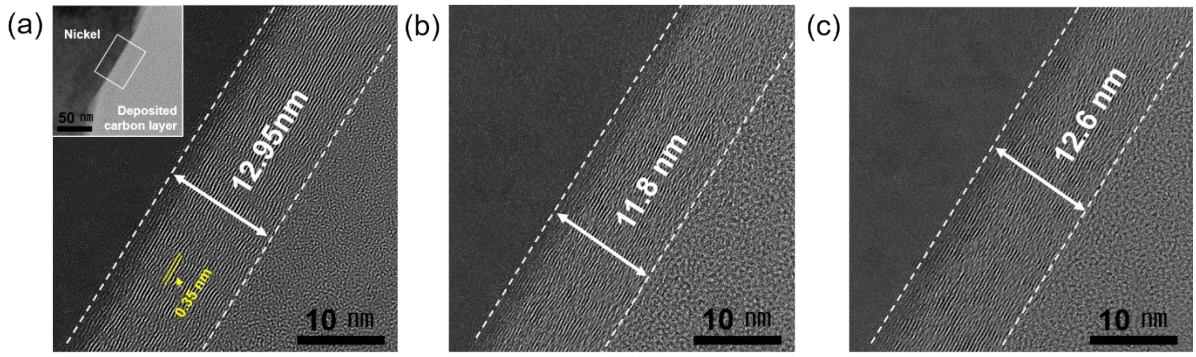

Fig. S6. (a-c) Cross-sectional TEM image showing an average graphene thickness of 12.45 nm grown at 1000 °C for 5 min on Ni foam. Yellow line in (a) shows the average interlayer spacing of 0.35 nm.

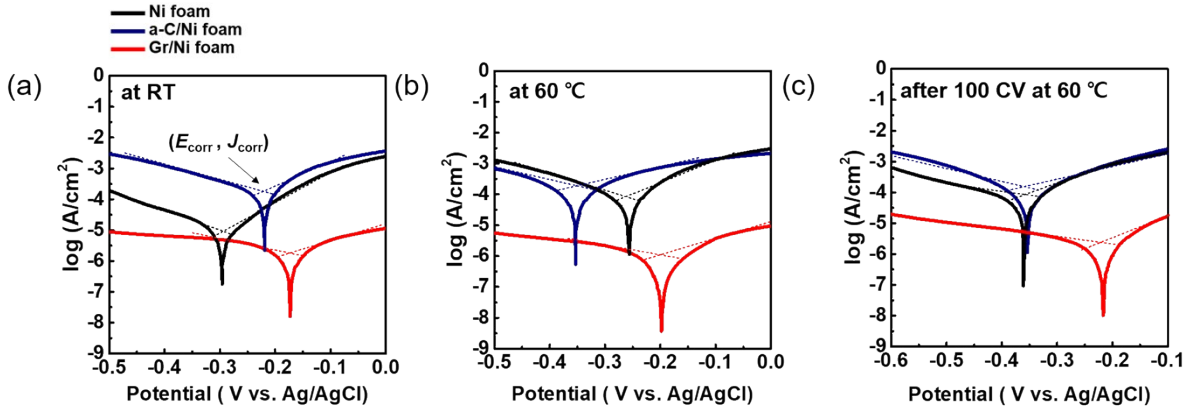

Fig. S7. (a-c) Tafel plots of bare Ni foam (black), a-C/Ni foam (blue) and Gr/Ni (red) foam samples at (a) RT, (b) 60 °C, and (c) after every 100 CV sweeps at 60 °C, with linear fits of cathodic and anodic curves (dashed line) giving the intersection at a corrosion potential (E_{corr}) and corrosion current density (J_{corr}).

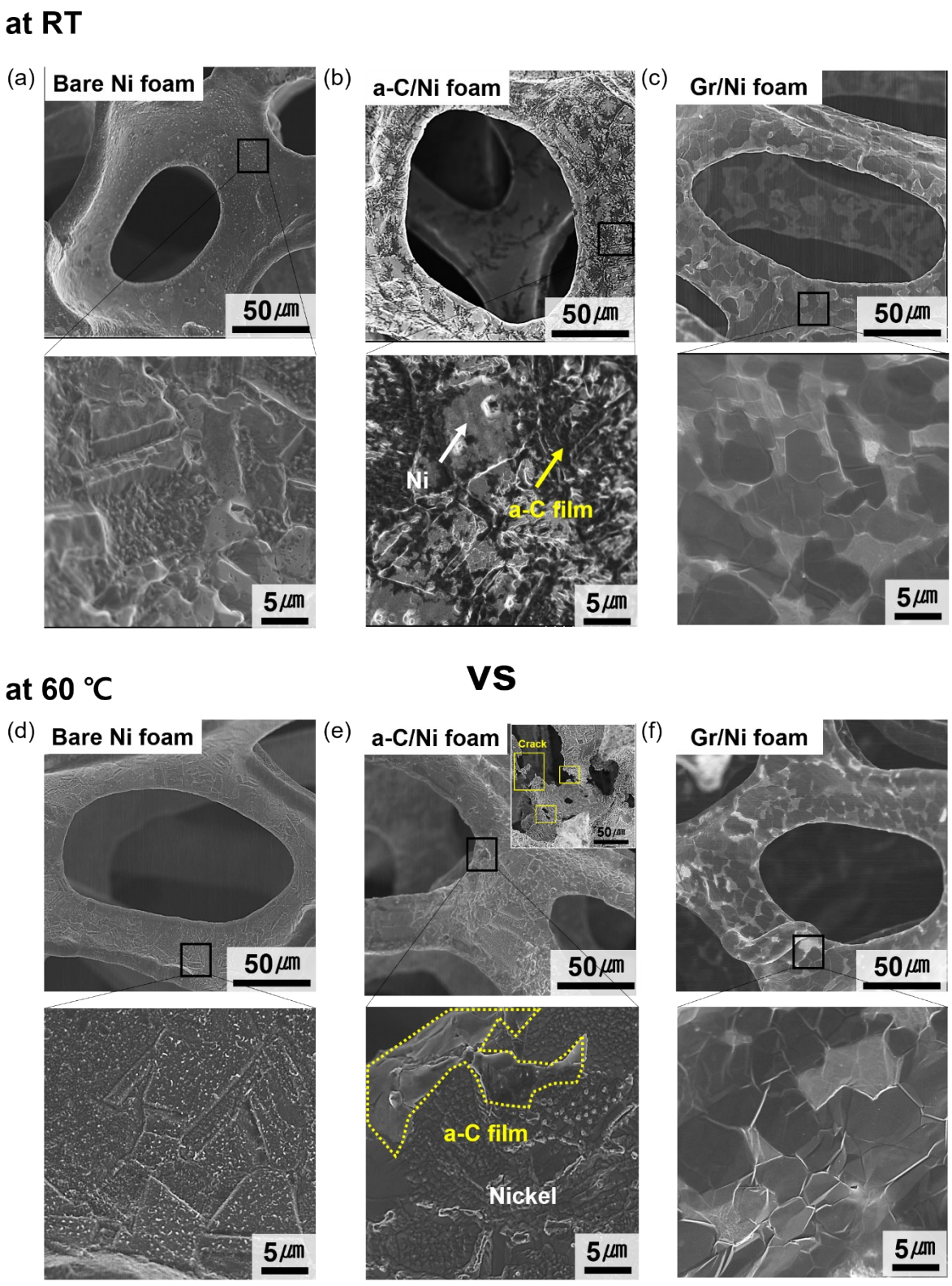

Fig. S8. The representative SEM images of three types of samples after polarization test (a-c) at RT and (d-f) at 60 °C; (a, d) Bare Ni foam, (b, e) a-C/Ni foam and (c, f) Gr/Ni foam, respectively. Samples of bare Ni foam show significantly etched surface due to Ni dissolution

in sulfuric acid (pH 1~1.5) containing 2 ppm HF. We found that a-C film is detached from Ni foam surface after the polarization test at RT and at 60 °C. Inset of Fig. S6e also shows crack in some area of sample. Graphene is in stark contrast with other samples under all condition. There are slight changes after polarization test at RT and at 60 °C.

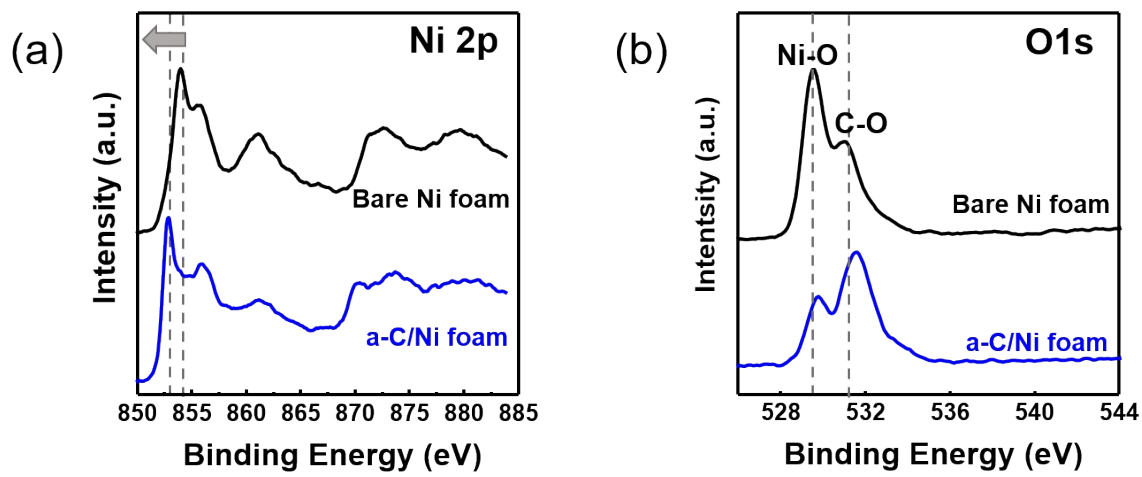

Fig. S9. XPS (a) Ni 2*p* and (b) O 1s line scans of bare Ni foam (black lines) and a-C/Ni foam (blue lines) that grown at 1000 °C for 3 min, respectively. The Ni $2p^{3/2}$ peak of the bare Ni foam show 853.8 eV, corresponding to the NiO. However, The Ni $2p^{3/2}$ peak of a-C/Ni foam (*i.e.*, annealed Ni foam at 1000 °C for 3 min) exhibits a shift toward lower binding energies and corresponds to Ni metal (852.6 eV). The results also accord with the O 1*s* line spectra of a-C/Ni foam.

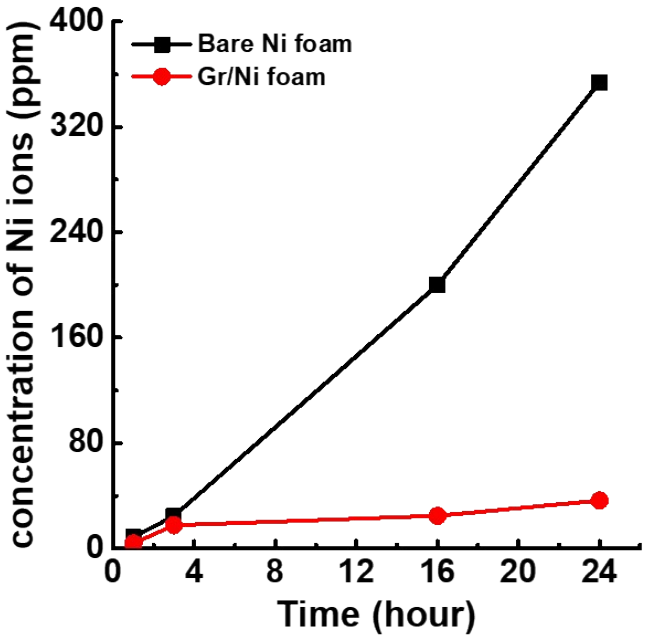

Fig. S10. Concentration of Ni^{2+} ions as a function of immersion time of bare Ni foam (black squares) and Gr/Ni foam (red circles) in sulfuric acid (pH 1~1.5) containing 2 ppm HF at 60°C. The concentration of dissolved ions was measured by ICP-OES.

Table S1. Comparison of the power densities in the PEMFCs employing the three-types of Ni foams (marked with the asterisk) and previously reported values in the conventional PEMFC cells with the graphite bipolar plates.

	Temp. (°C)	**SR (anode/cathode)**	**RH (%) (anode/cathode)**	**Pressure (bar) (anode/cathode)**	**Power density at 0.5V (mW/cm^2)**
Ni foam*	60	2.0/1.8	50/50	1.5/1.5	**521**
a-C/Ni foam*	60	2.0/1.8	50/50	1.5/1.5	**873**
Gr/Ni foam*	60	2.0/1.8	50/50	1.5/1.5	**967**
[1]	50	1.2/3.0	50/50	1.0/1.0	**325**
[2]	60	1.4/3.0	100/100	0.35/0.35	**400**
[3]	65	1.5/2.5	100/100	1.0/1.0	**300**
[4]	75	1.5/2.0	100/100	1.0/1.0	**380**
[5]	65	-	100/100	1.0/1.0	**310**
[6]	70	1.5/2.0	100/100	2.0/2.0	**350**

Supplementary references

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