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Supplementary Materials for

Nanochannel-dependent power generation performance of NiAl-LDH/SiO_2 based generators driven by natural water evaporation

Jiangying QU*[a], Jingjing TU[a], Chunqian GUAN[a,b], Feng GAO*[a], Yunhao ZANG[a]

[a]School of Environment and Civil Engineering, Dongguan University of Technology, Dongguan 523808, P. R. China

[b]School of chemistry and Chemical Engineering, Liaoning Normal University, Dalian 116029, China

***Corresponding author at:** Dongguan University of Technology, Dongguan,523808, P. R. China

E-mail address: qujianggaofeng@163.com; fenggao2003@163.com

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1.Characterization

For the zeta potential test, dispersed the NiAl-LDH/SiO_2-x nm (x=4,9 and 14) powders in DI water and tested by potentiometer (Zetasizer Nano ZSP; UK). The morphology and structure of NiAl-LDH/SiO_2-x nm (x=4, 9 and 14) were characterized by X-ray diffraction patterns (XRD; D/max-2500/PC, Japan); SEM (Nova Nano 450, USA) and transmission electron microscope (TEM; Talos F200X, USA). The X-ray photoelectron spectroscopy (XPS; Escalab 250, USA) measurements were performed on a photoelectron spectrometer with Al Kα (1486.6 eV). The nanochannel structure constructed by NiAl-LDH/SiO_2-x nm (x=4, 9 and 14) was tested by nitrogen adsorption/desorption isothermal technology (BET; Micrometrics ASAP 2020, USA). All output electrical performance was tested by a digital source meter (Keithley; 2450, USA). The temperature and humidity under test conditions were recorded by a temperature and humidity meter (THtool-v150; China).

2. The assembly of natural water evaporation generator (NWEG)

The NWEG was assembled as followed. The polyethylene terephthalate (PET) was used as a flexible substrate, and the generation material was NiAl-LDH/SiO_2. Multiwalled carbon nanotubes (MWCNTs) were performed as the electrode materials. Two electrodes were connected by the copper wires using epoxy to encapsulate.

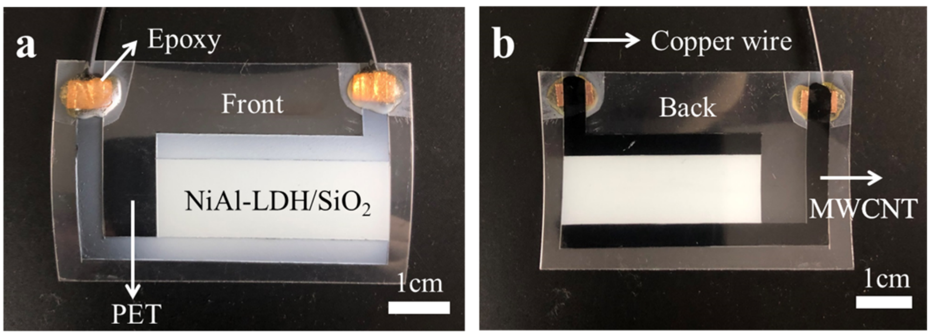

Fig S1. The assembly of NiAl- LDH/SiO_2 based NWEG.

3. The test for NWEG performance

The NWEG was kept in a container to test the output electrical performance in Fig S2a.

A temperature and humidity meter recorded the temperature and humidity under ambient conditions as shown in Fig S2b. The indoor humidity was controlled by an intelligent dehumidifier in Fig S2c. All the output electrical performance were tested by a digital source meter (Keithley; 2450, USA) in Fig S2d.

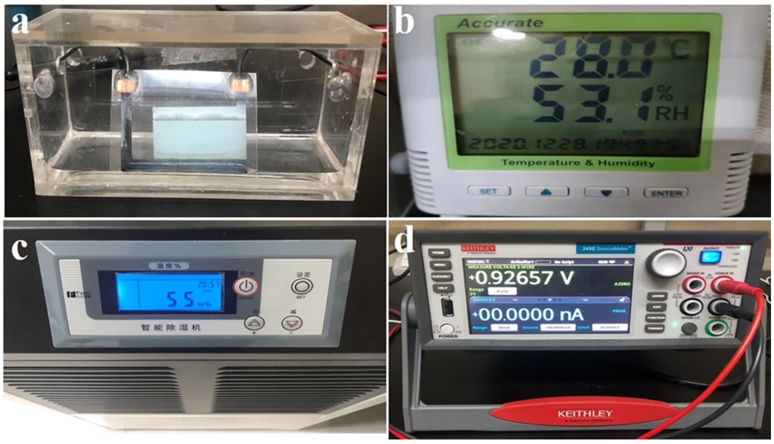

Fig S2. The diagram of each instrument for testing of NWEG performance.

4. Test the Tyndall effect of NiAl-LDH/SiO_2-9 nm

Tyndall effect was tested by dispersing NiAl-LDH/SiO_2-9 nm powder in DI water to form a homogeneous solution. Then a red straight light from a laser pen passed through the solution to evident a strong Tyndall effect.

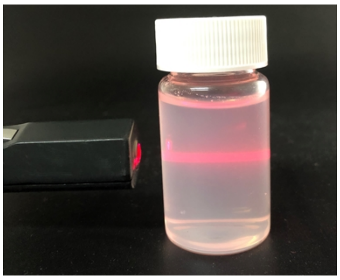

Fig S3. A strong Tyndall effect of NiAl-LDH/SiO_2-9 nm dispersion liquid.

5. The elemental content of NiAl-LDH/SiO_2-9nm sample

The XPS quantifies the atomic elemental content of C 1s, O 1s, Ni 2p, Al 2p and Si 2p of NiAl-LDH/SiO_2-9 nm, the detail dates are shown in Table S1.

Table S1. The atomic content of NiAl-LDH/SiO_2-9nm

Name	Elemental content (at. %)
C 1s	16.00
O 1s	44.86
Ni 2p	18.37
Al 2p	7.92
Si 2p	12.85

6. The effect of side evaporation area on output electrical performance of NWEG

When the flow potential is generated, the area of side evaporation will affect the output electrical performance. In this work, the side evaporation area was regulated to area I, II, III and IV by the plastic film and tape (Fig S4a). With the coverage area expands, the V_{oc} of pristine, area I, II, III to IV decreases from 1.40, 1.10, 0.50, 0.02 V to 0.70 mV, respectively (Fig S4b). Correspondingly, the I_{sc} also decreased from 240, 200, 100, 25 to 11 nA, respectively (Fig S4c). Moreover, the pristine NWEG has the full area for side evaporation (100%) and achieves the V_{oc} of 1.40 V. When the side evaporation area decreases to area I (66%), the V_{oc} drops to 21%. Likewise, the V_{oc} of area II (33%) is 55% lower than area I. Until the side evaporation area is entirely covered, the V_{oc} of area III is 65% lower than area II (Fig S4d). In summary, the output electrical performance decreases with the decrease of the side evaporation area.

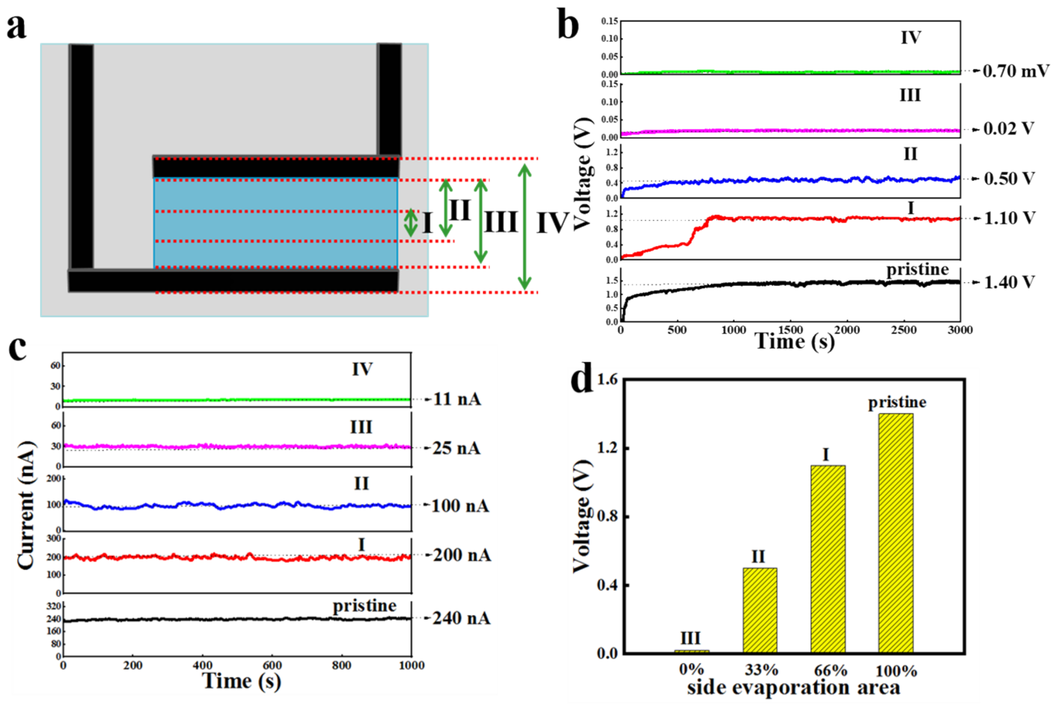

Fig S4. (a) Schematic diagram of the side evaporation area with the plastic film and tape to cover the different area. (b) The V_{oc} of different side evaporation area. (c) The I_{sc} of different side evaporation area. (d) A histogram of voltage and side evaporation area.

7. The V_{oc} and I_{sc} of different thicknesses and heights of the NiAl-LDH/SiO_2-9 nm film

The thickness of NiAl-LDH/SiO_2-9 nm film is 6, 12 and 25 μm, which assembly the NWEGs and exhibit the V_{oc} of 2.00, 1.40 and 0.50 V, the I_{sc} of 50, 240 and 260 nA, respectively. Therefore, the maximum output power is obtained when the film thickness is12 μm. Similarly, the height of NiAl-LDH/SiO_2-9 nm film is 1, 1.5 and 2 cm, results the NWEGs perform the V_{oc} of 0.65, 1.40 and 1.80, and the I_{sc} of 120, 240 and 175 nA, respectively. Which achieve the maximum output power with the film height of 1.5 cm.

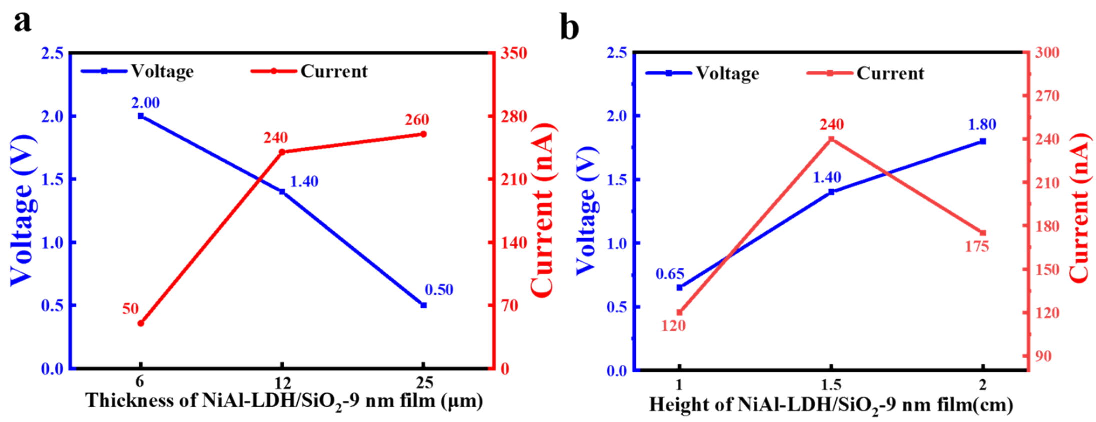

Fig S5. The influence of different (a) heights and (b) thicknesses of the NiAl-LDH/SiO_2-9 nm films on the voltage and current.

8. The V_{oc} at different RH

Natural water evaporation progress is affected by humidity. The NWEGs have been tested under the RH of 40%, 55% and 70%, the V_{oc} is 2.00, 1.40 and 0.50 V, respectively. It indicates the output electrical performance is inhibited under high humidity.

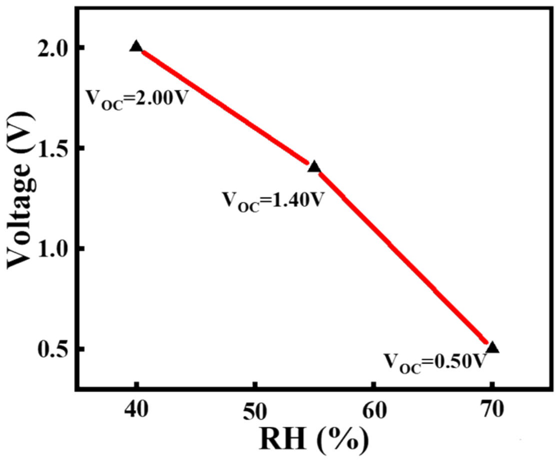

Fig S6. V_{oc} of the NWEGs under different humidity.

9. The test of exchange positive and negative electrodes

In order to exclude the primary battery effect, the test of exchange positive and negative electrodes is shown in Fig S7. With the exchange, the voltage has also changed the positive to negative, which indicates the output voltage is generated from natural water evaporate rather than electrochemical reaction.

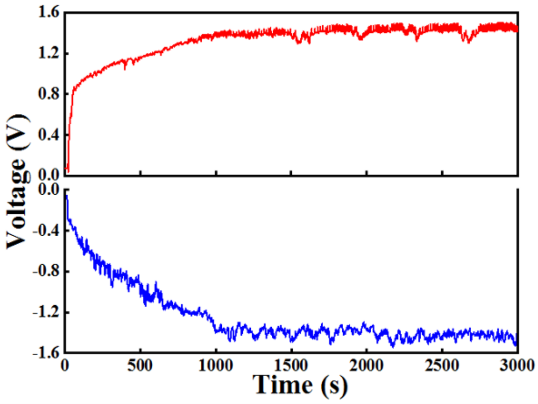

Fig S7. The test of exchange positive and negative electrodes to exclude primary battery effect.

10. The V_{oc} and I_{sc} of the NWEGs under different external load resistance

The blue lines represent the V_{oc} gradually increases from 0.25 to 1.11 V as the external load resistance changes from 1 to 10 MΩ. Simultaneously, the I_{sc} represented by the red lines also decreases from 200 to 30 nA depending upon the external load resistance (Fig. S8a). The correlation of V_{oc} and I_{sc} under different loads is shown in Fig. S8b.

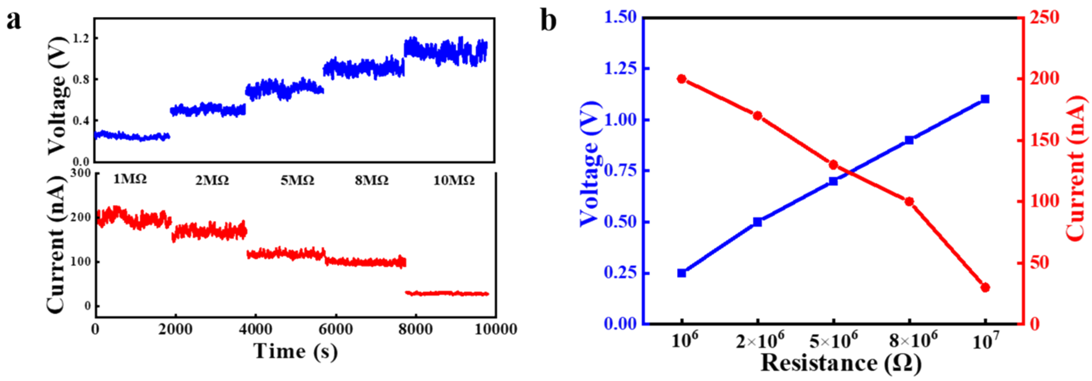

Fig S8. (a) The V_{oc}-t and I_{sc}-t performance of the NWEGs under different external load resistances. (b) Correlation of V_{oc} and I_{sc} with applied load resistance.