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Electronic Supplementary Information

High-energy, flexible micro-supercapacitor by one-step laser fabrication of self-generated nanoporous metal/oxide electrode

Jaehak Lee[a], Jaeyoung Seok[a], Seokwoo Son[a], Bongchul Kang[b, *], Minyang Yang[a, *]

[a] Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 305-338, Republic of Korea, *Email: myyang@kaist.ac.kr

[b] Department of Mechanical System Engineering, Kumoh National Institute of Techonology, Gumi 730-701, Republic of Korea, Email: kbc@kumoh.ac.kr

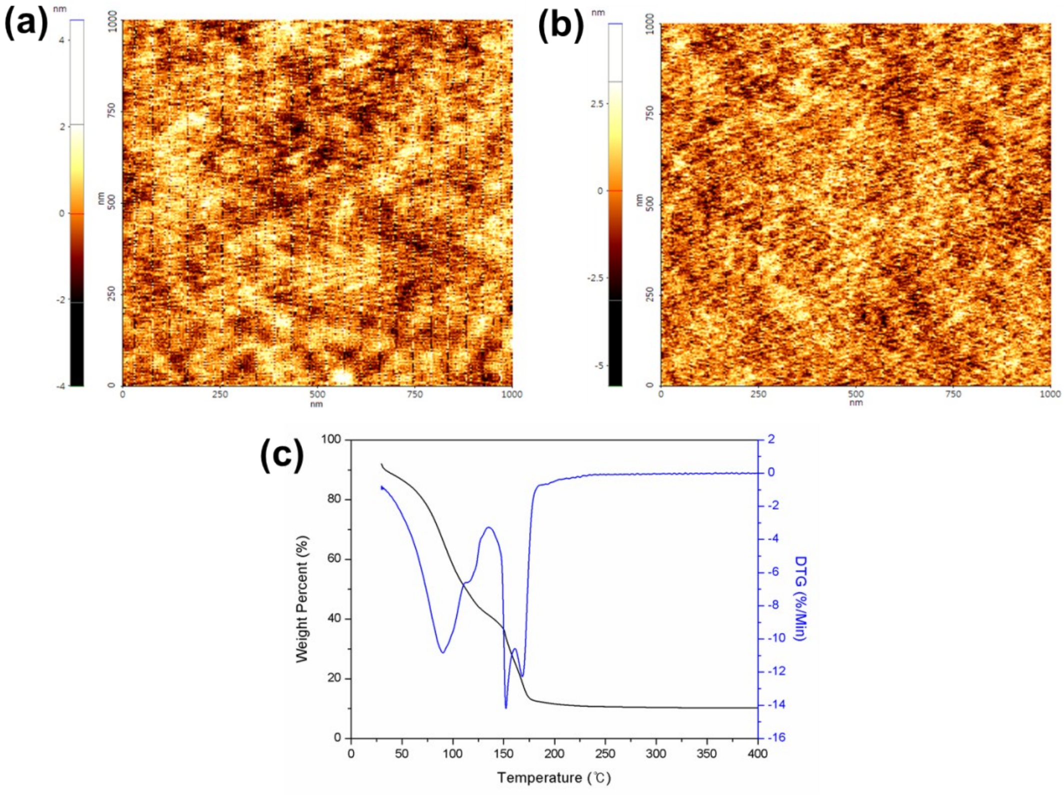


Fig. S1 AFM measurement of (a) Bare PI film and (b) Laser-irradiated PI film. (c) TGA data of organometallic complex.

As shown in Fig. S1, laser process used in this work does not react with PI substrate. Since the temperature to complete the growth sintering from the hybrid suspension is approximately 250 °C that is within a thermal limit of PI film, as shown in the TGA data,

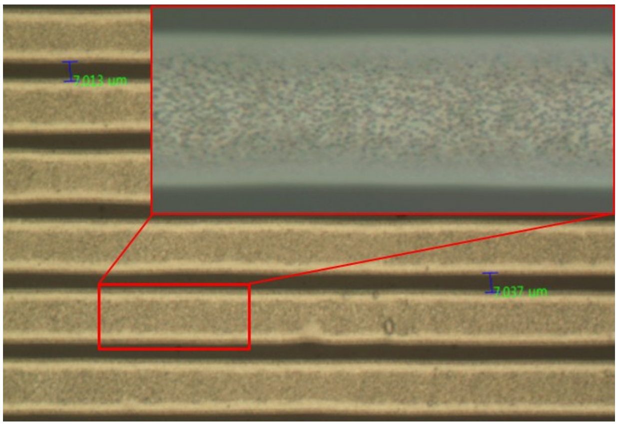


Fig. S2 Finer width nanoporous silver conductor fabricated by the f-theta lens for an objective lens

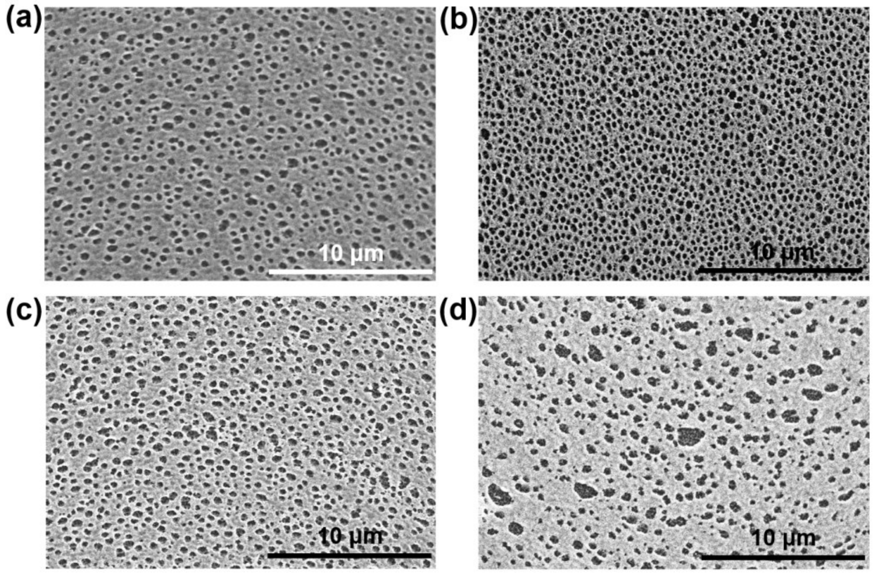


Fig. S3 SEM images of NPS electrode surface depending on laser scan rates i.e. (a) 10 mm/s, (b) 14 mm/s, (c) 20 mm/s, (d) 32 mm/s

Table S1 Pore distribution and approximated NPS conductors.

Scan rates	2 mm/s	10 mm/s	14 mm/s	20 mm/s	32 mm/s
Total number of pores	N/A	1049	2876	1030	611
Average diameter (nm)	N/A	256	219	311	360
Standard deviation of average diameter (nm)	N/A	140	110	123	180
Approximated surface area (μm^2)	425	660	955	730	623

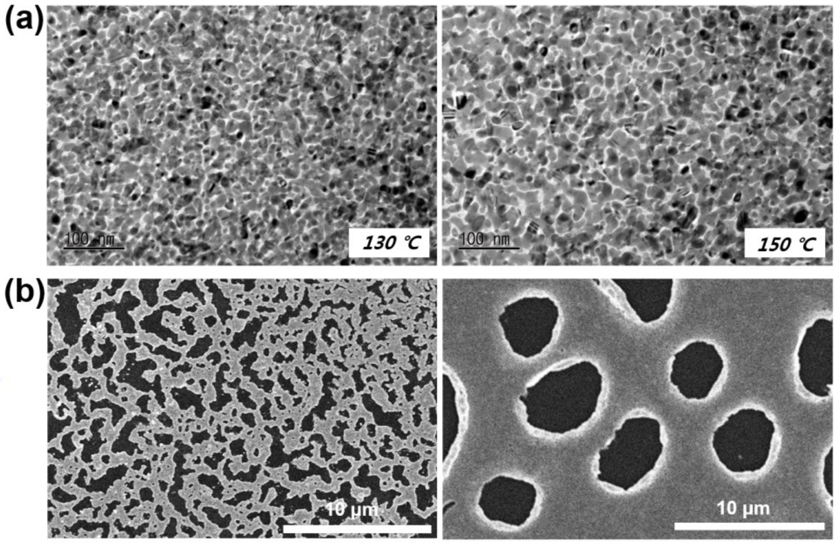


Fig. S4 (a) TEM crystallographic images of organometallic solution with baking temperatures. (b) SEM images of the laser-sintered silver electrodes with baking temperatures.

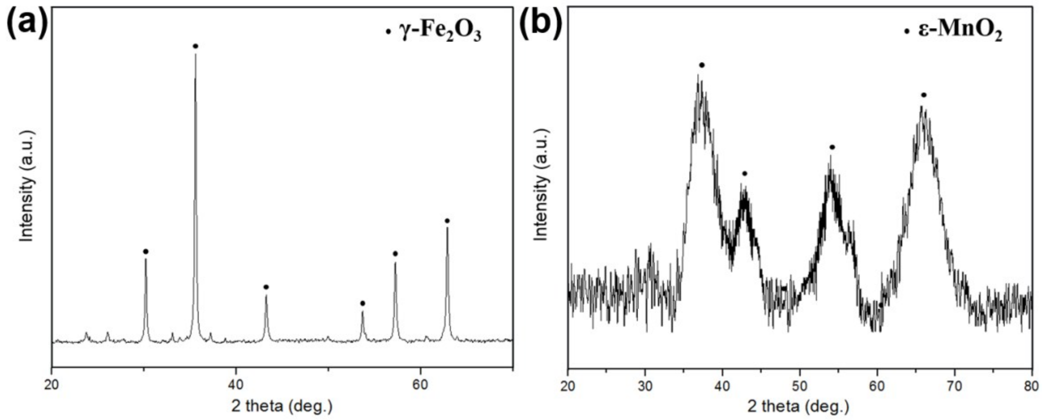


Fig. S5 XRD measurements of (a) Fe_2O_3 and (b) MnO_2-deposited NPS conductors.

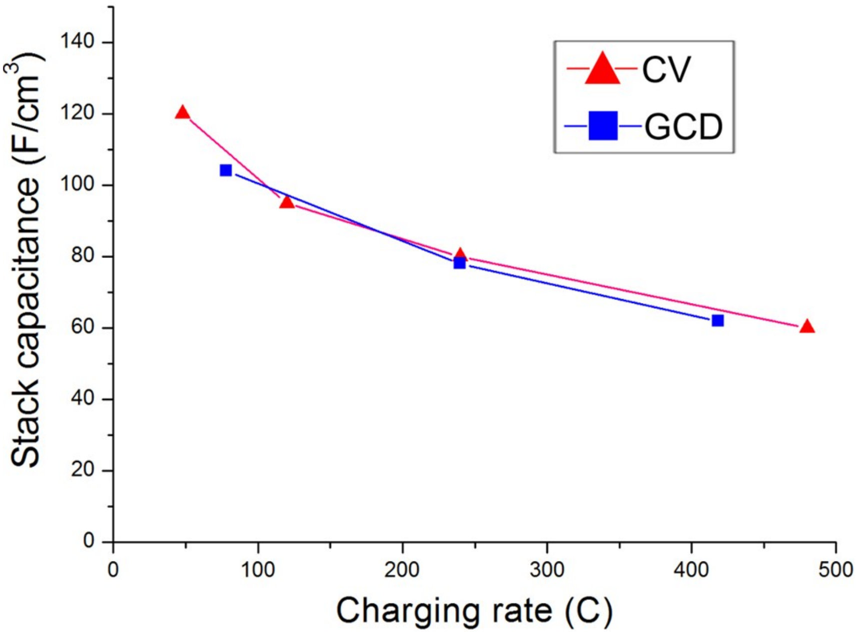


Fig. S6 Stack capacitances of asymmetric MSC that calculated from CV and GCD curves.

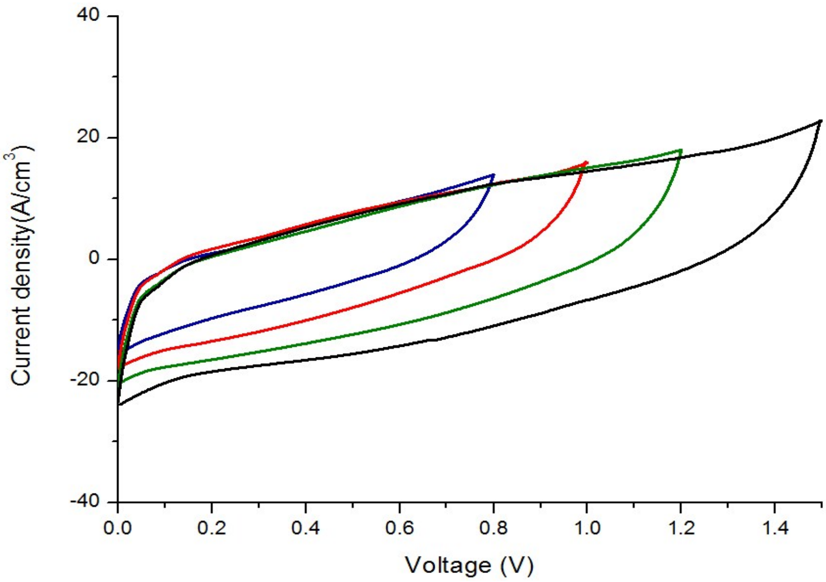


Fig. S7 CV curves of the asymmetric micro-supercapacitor with increase of operating voltage.

Calculations of volumetric stack capacitance, and energy and power density.

The performances of the devices were calculated based on their CV curves. The capacitance was calculated by integrating the current during CV (i) vs. potential (V) plots using the following equation:

$$C_{device} = \frac{\int_{V_-}^{V_+} idV}{2v * \Delta V} \quad (1)$$

where v is the scan rate (V/s) and ΔV ($\Delta V = V_+ - V_-$) is the potential range. Volumetric stack capacitances (C_v, F/cm^3) were calculated based on the volume of the device:

$$C_v = \frac{C_{device}}{V_{elec}} \quad (2)$$

where V_{elec} refer to the volume (cm^3) of the electrode which includes the silver and metal oxide. The energy density of the device (E, Wh/cm^3) was obtained from the following equation:

$$E = \frac{C_{device}}{7200 * V_{device}} \Delta V^2 \quad (3)$$

where V_{device} is the volume (cm^3) of the whole device which include the electrode, the current collector and the gap between the electrodes. The power density (P, W/cm^3) of the device was calculated by following equation:

$$P = \frac{E}{t} \quad (4)$$

where t is the discharge time in hours.

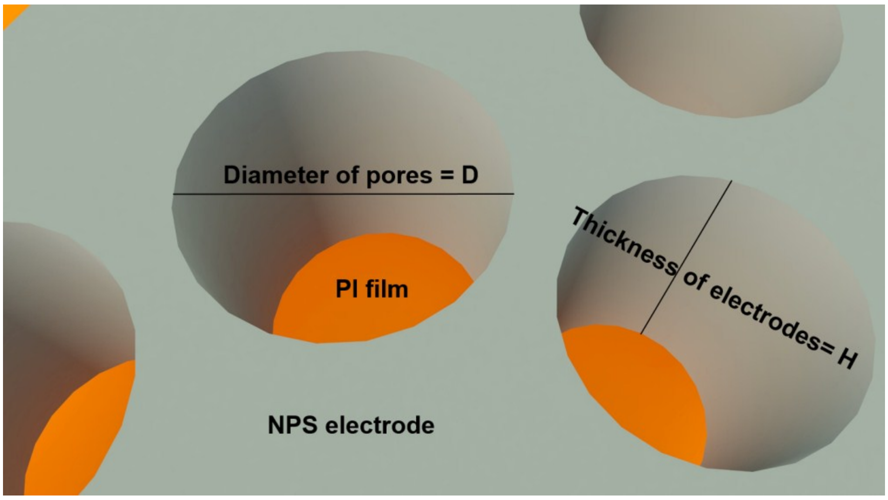
The volumetric stack capacitances from the GCD curve was calculated based on following equation:

$$C_{v,g} = \frac{i * \Delta t}{\Delta V * V_{elec}} \quad (5)$$

where $C_{v,g}$ is the volumetric stack capacitance from the GCD curve, i is discharge current, and Δt is the discharge time in seconds.

Approximation of surface area of NPS electrodes

As shown in AFM measurement data in Fig 2b, the NPS electrodes have fairly uniform thickness over the whole area, and the each pores are in touch with the PI film, as illustrated in the following figure.



We assumed that the perfect circular pores are distributed on PI film with the size distribution following the above histogram, and the surface area of electrodes are approximated by following equation:

$$A_{surface} = A_{image} + \sum_{all\,pores} \pi(DH - \frac{D^2}{4})$$

where $A_{surface}$ is total surface area of NPS electrode, A_{image} is an area of SEM image (425 μm^2), D is the diameter of a pore, and H is the thickness of NPS electrodes.