Title
First Demonstration of 3D Printed Periodic Macroporous Graphene Aerogels as Supercapacitor Electrodes with Exceptional Rate Capability

Author
Liu, Tianyu

Publication Date
2016-04-29

First Demonstration of 3D Printed Periodic Macroporous Graphene Aerogels as Supercapacitor Electrodes with Exceptional Rate Capability

Tianyu Liu,[a] Cheng Zhu,[b] Marcus A. Worsley,[c] and Yat Li [a*]

[a] Department of Chemistry and Biochemistry, University of California, Santa Cruz, California 95064, US
[b] Engineering Directorate, Lawrence Livermore National Laboratory, Livermore, California 94550, US
[c] Physics and Life Science Directorate, Lawrence Livermore National Laboratory, Livermore, California 94550, US

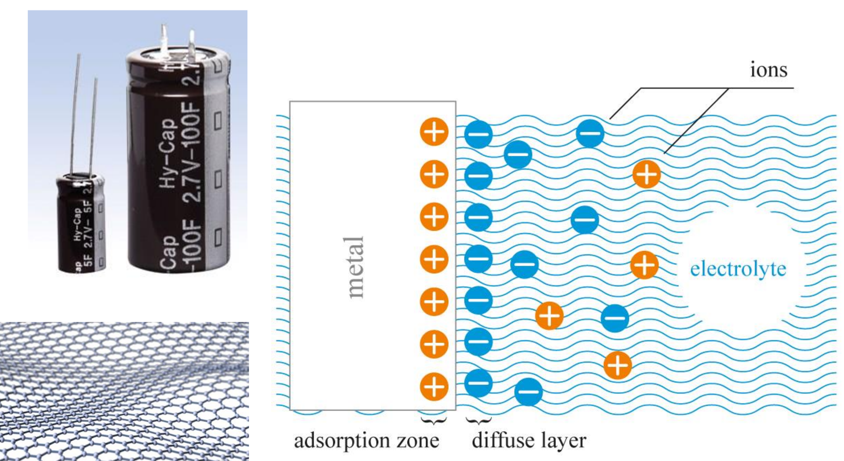
Introduction

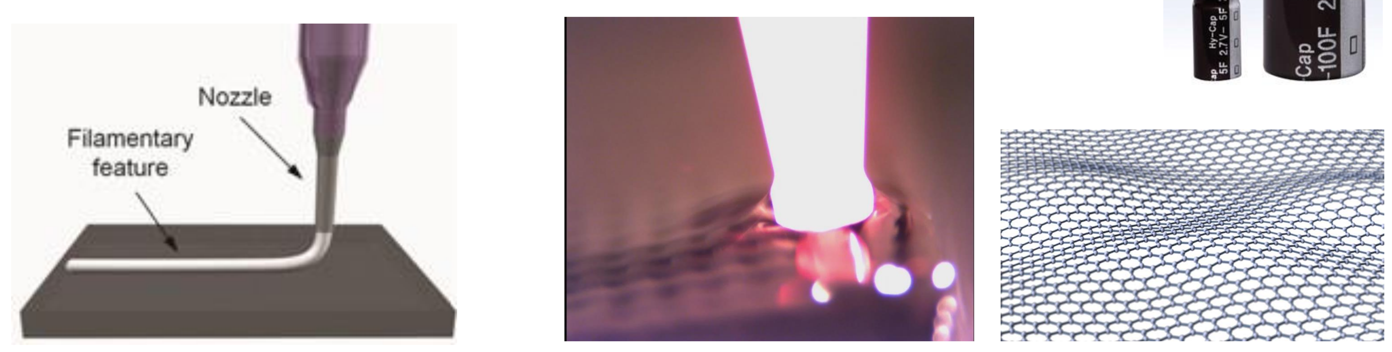
Supercapacitors

- Electrical energy storage devices for portable electronics, memory backup systems, and hybrid electric vehicles
- Higher capacitance than physical capacitors, higher power density and longer lifetime than lithium-ion batteries
- Graphene: Electrical Double Layer Capacitance (EDLC)

3D Printing Technology

- Direct ink writing
- Fabrication of 3D periodic structures
- Facilitate ion diffusion within thick electrodes





Fabrication

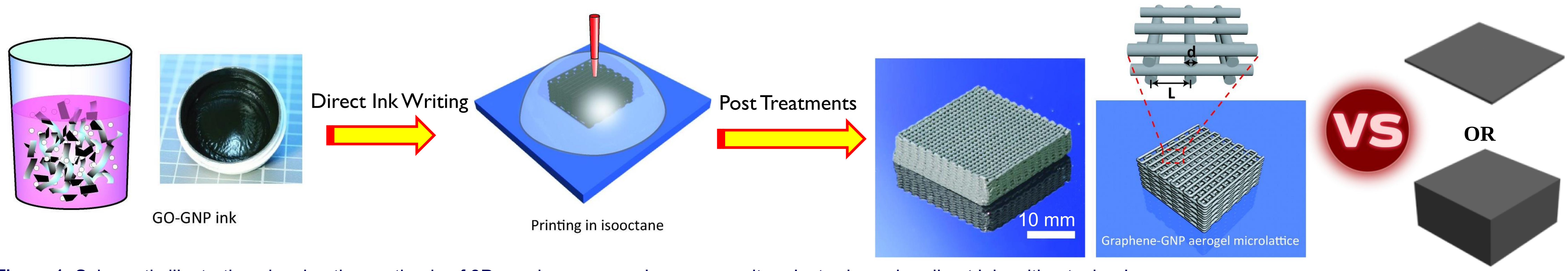


Figure 1. Schematic illustration showing the synthesis of 3D graphene-aerogel supercapacitor electrodes using direct ink writing technology.

Physical Properties

Table 1. Compositions and textural properties of different electrodes

Sample	GO (wt%)	GNP (wt%)	SiO_2 (wt%)	SA_{BET} ($m^2 \cdot g^{-1}$)	Resistance (W•sq^{-1})
GO-SiO_2	3.3	0.0	16.7	739	61.1
GO-GNP-SiO_2-1	3.3	4.2	12.5	302	10.3
GO-GNP-SiO_2-2	3.3	12.5	4.2	418	0.96
GO-GNP	3.3	16.7	0.0	436	2.22

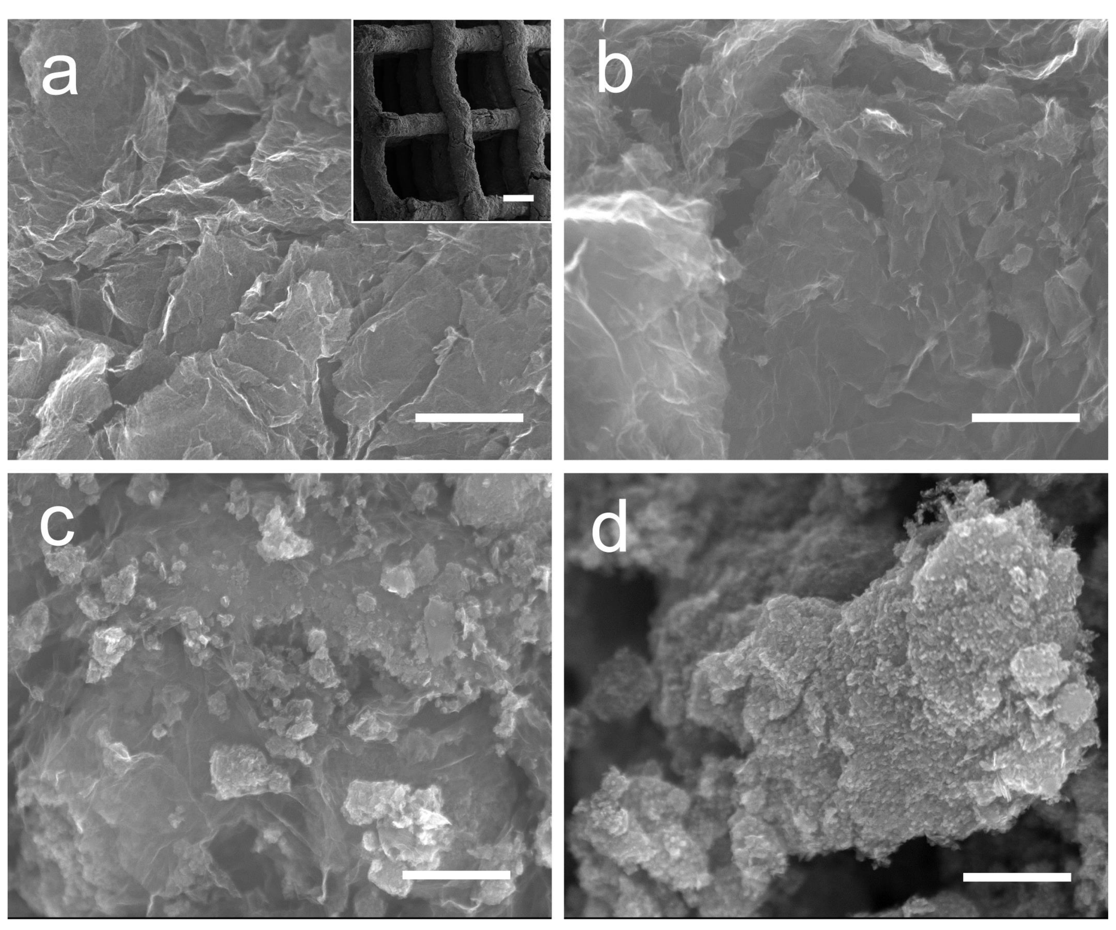


Figure 2. SEM images collected for different samples. (a) GO-SiO_2 with the inset shows the cubic aerogel lattice, (b) GO-GNP-SiO_2-1, (c) GO-GNP-SiO_2-2 and (d) GO-GNP. The scale bar in the inset represents 250 μm and other scale bars represent 1 μm.

Capacitive Performance of Single Electrodes

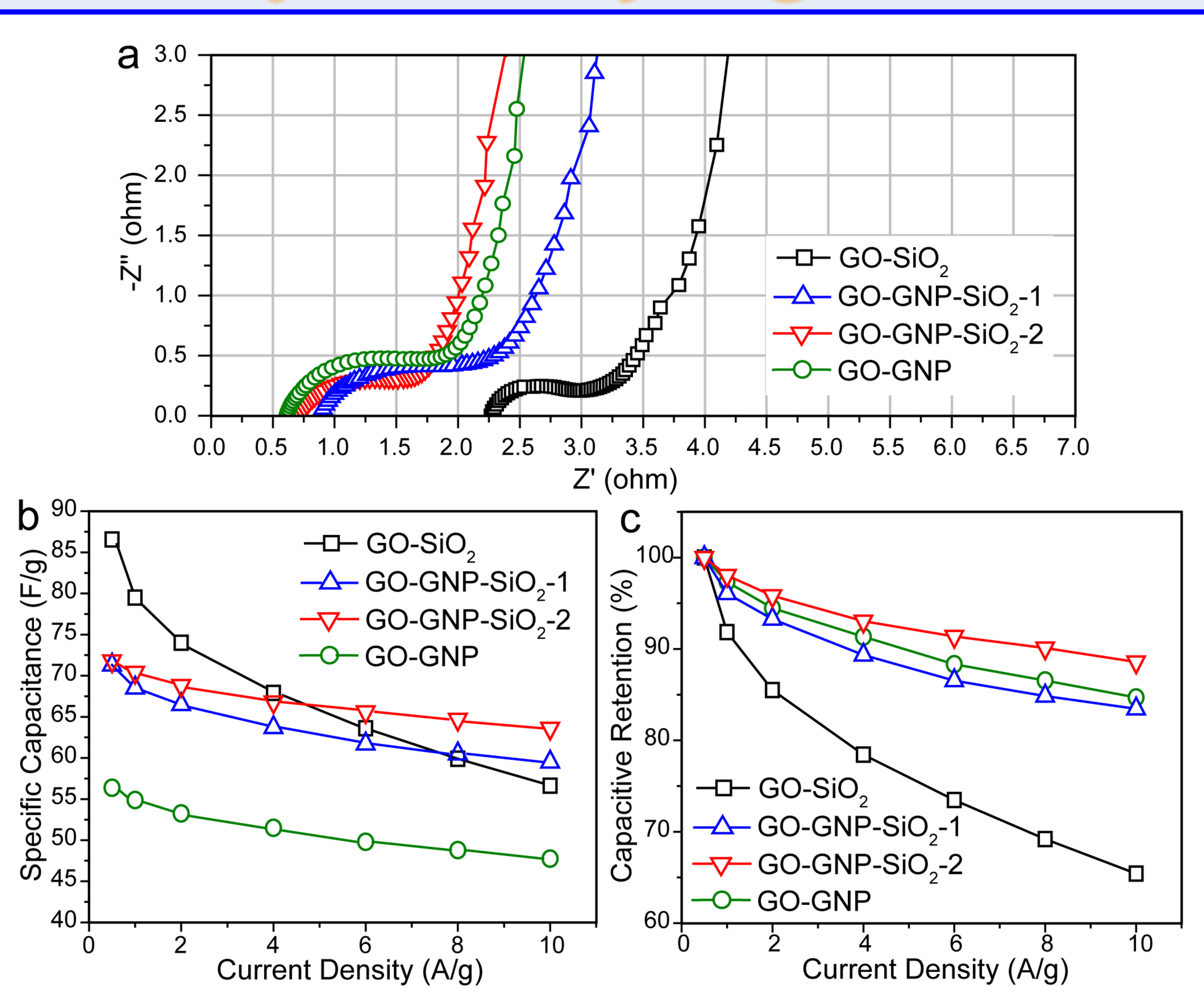


Figure 3. (a) Nyquist plots of 3D-GCAs with different amount of GNP and silica fillers. (b) Specific capacitance and (c) capacitive retention of 3D-GCAs calculated as a function of current density.

Capacitive Performance of Supercapacitors

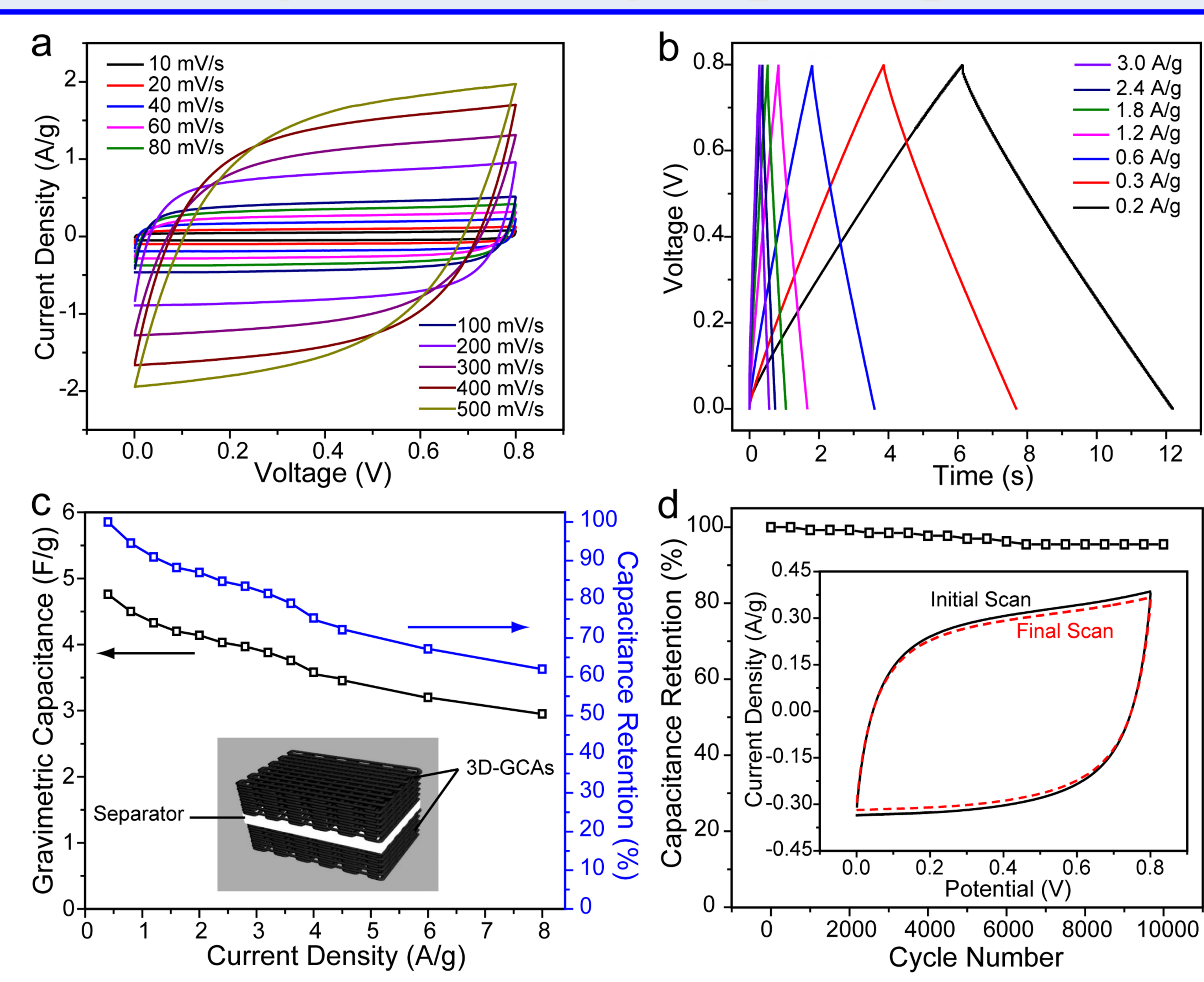


Figure 4. (a) Cyclic voltammograms. (b) Charge and discharge profiles. (c) Rate capability performance. Inset: schematic illustration of the device. (d) Cycling performance. Inset shows the first and last cyclic voltammograms collected during the cycling stability test.

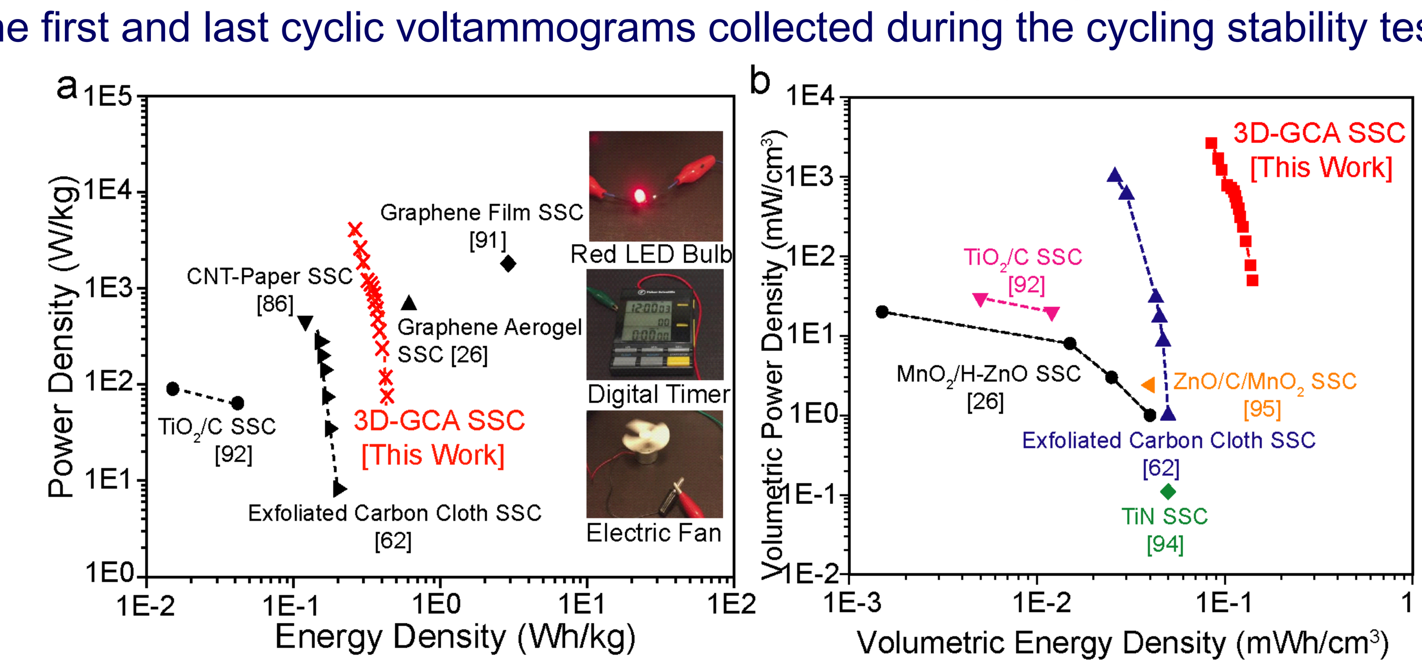


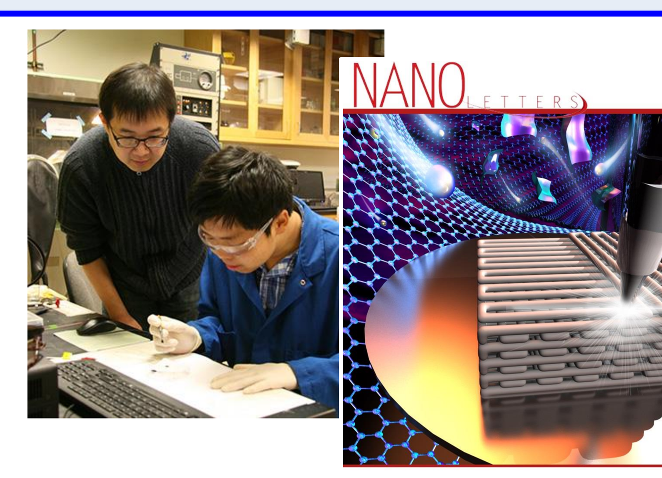
Figure 5. Ragone plots of energy and power densities based on a) mass and b) volume.

News

UNIVERSITY OF CALIFORNIA SANTA CRUZ NEWSCENTER

Researchers use 3D printing to make ultrafast graphene supercapacitor

Printable, ultralight graphene aerogel opens the door to novel designs of highly efficient energy storage systems for smartphones and other devices



"Their results open the door to novel, unconstrained designs of highly efficient energy storage systems for smartphones, wearables, implantable devices, electric cars and wireless sensors."

http://news.ucsc.edu/2016/02/graphene-supercapacitor.html

Acknowledgment

This work was supported by Lawrence Livermore National Laboratory under the auspices of the U.S. Department of Energy under Contract DE-AC52-07NA27344, through LDRD award 14-SI-004 and 13-LW-099.