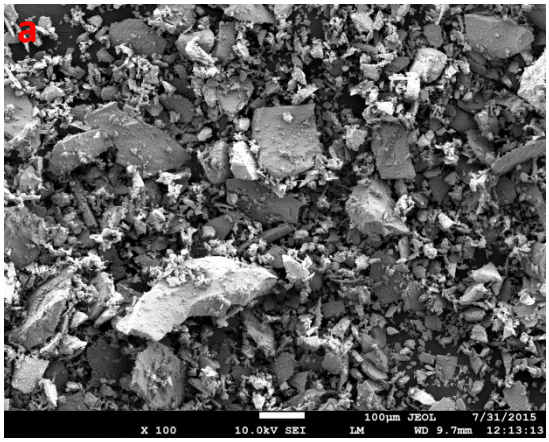
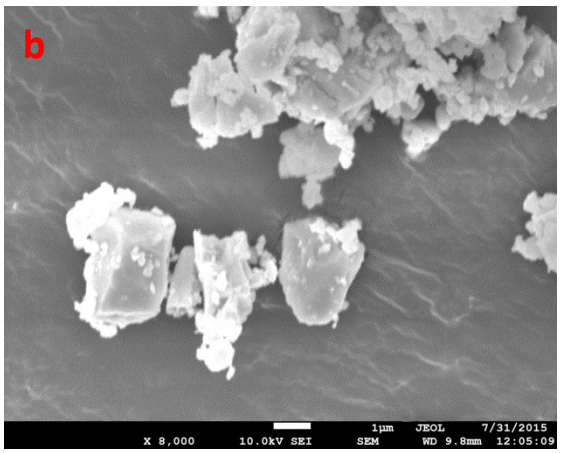
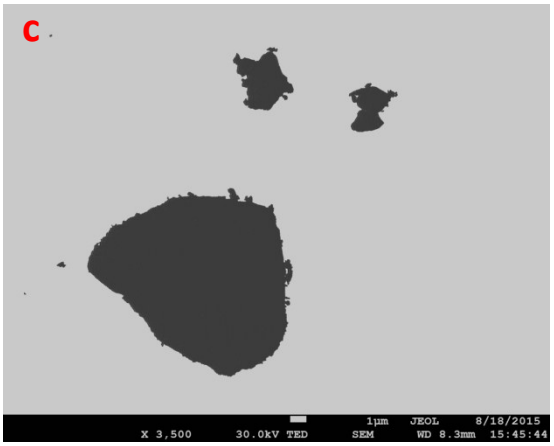
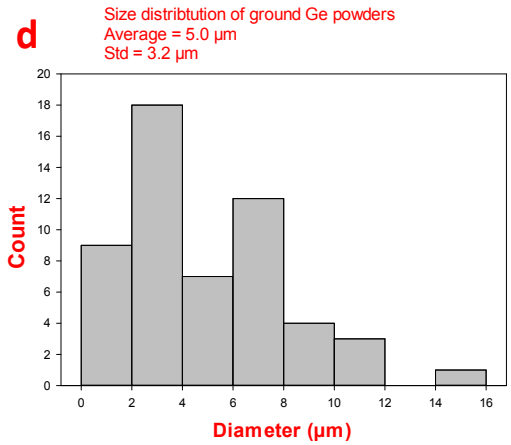
Electronic Supplementary Material (ESI) for RSC Advances.

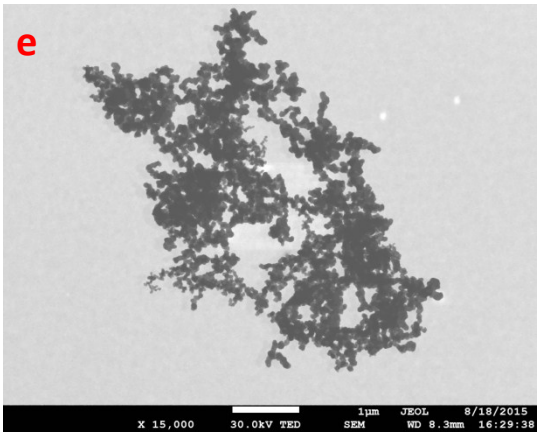
Supporting information 1: Scanning electron microscope images of (a) as-received Ge powders (100 meshes); (b) ball-milled Ge powders (8 hrs at 30 rpm); (c) transmission electron microscope image and (d) size distribution of ball-milled Ge powders; (e) transmission electron microscope image and (f) size distribution of carbon black nanoparticles. Scale bars for b, c and e are 1 µm; scale bar for a is 100 µm. Note: because TEM only gives 2-D projected images of 3-D particles and these Ge powders are highly irregular in shape, we use Heywood diameter to represent the size of Ge powders ($d_p = 2\sqrt{\frac{A}{\pi}}$), where d_p is the equivalent diameter of the circle that has the same area as the projected area from TEM image and A is the projected area of particle from TEM image.(Clark, 1984)

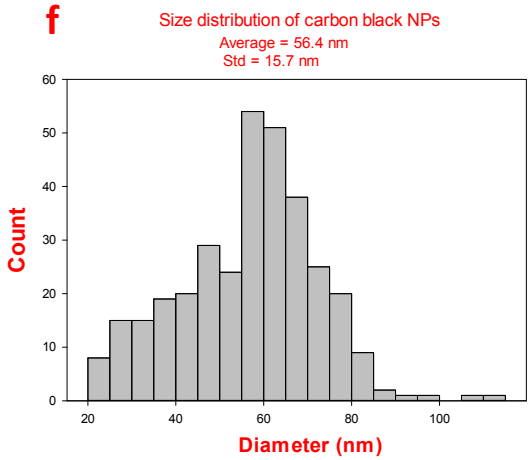






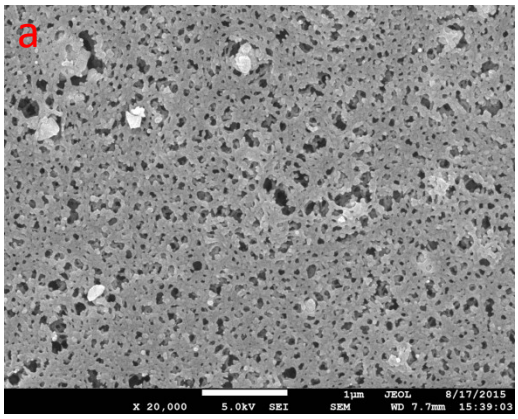


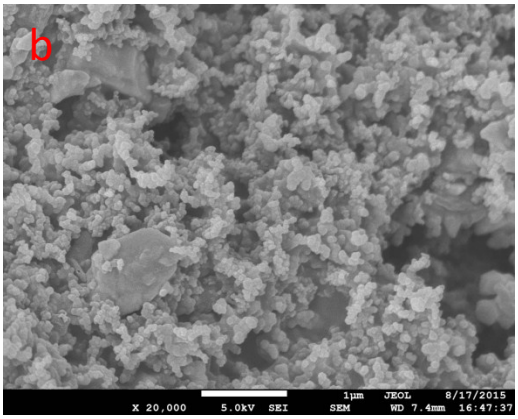


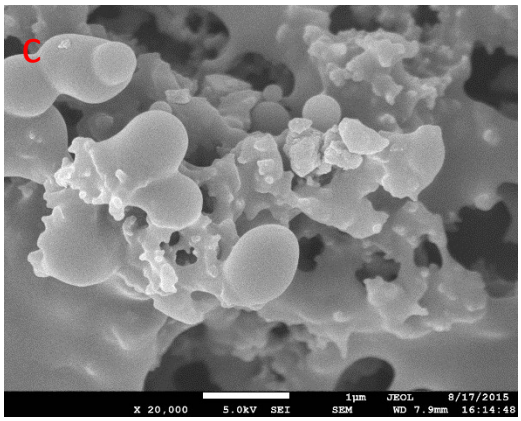


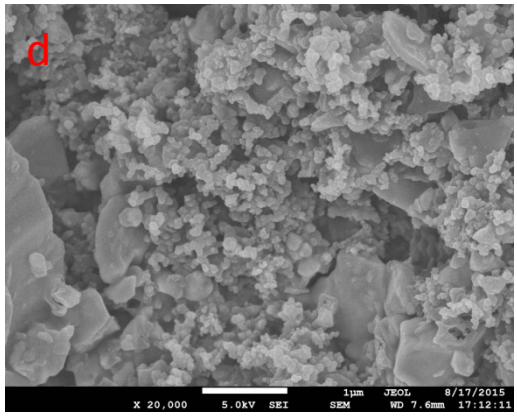
CLARK, J. P. 1984. HANDBOOK OF POWDER SCIENCE AND TECHNOLOGY - FAYED,ME, OTTEN,L. *Food Technology,* 38**,** 121-121.

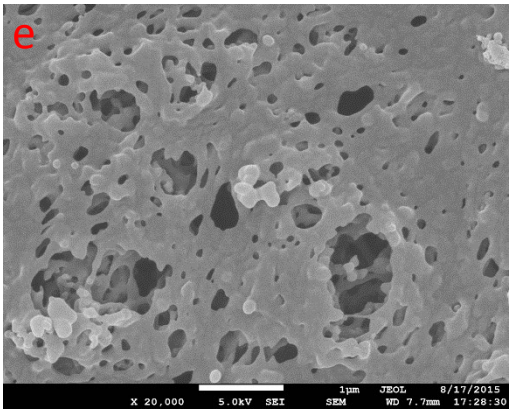
Supporting information 2: SEM images of Ge asymmetric membranes. (a) 100 µm thick before carbonization (Ge 15WT100M, top view); (b) 100 µm thick after carbonization at 800 °C for 2 hrs (Ge 15WT100M, top view); (c) 250 µm thick before carbonization (Ge 15WT250M, top view); (d) 250 µm thick after carbonization at 800 °C for 2 hrs (Ge 15WT250M, top view); (e) top view and (f) cross-section view of polysulfone/carbon black membranes (PS/CB 15WT250M) before carbonization; (g) top view and (h) cross-section view of polysulfone/carbon black membranes (PS/CB 15WT250M) after carbonization at 800 °C for 2 hrs.

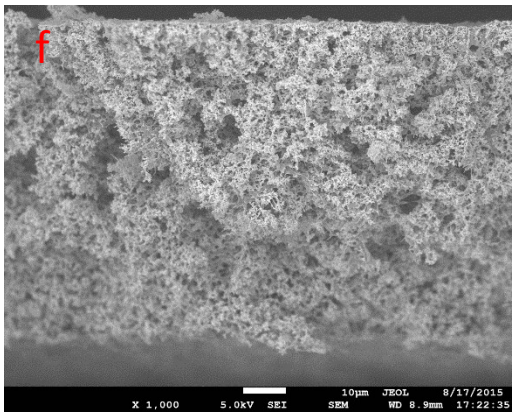


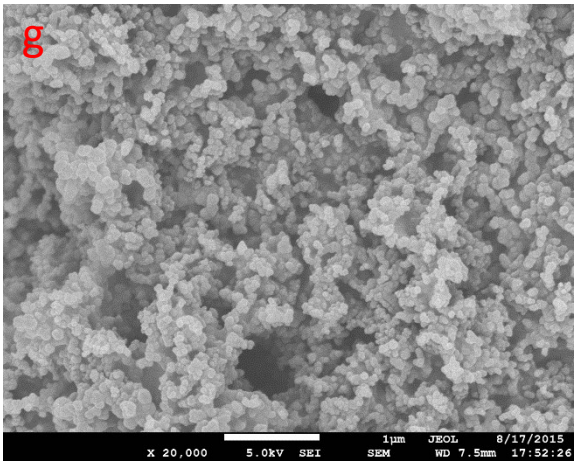








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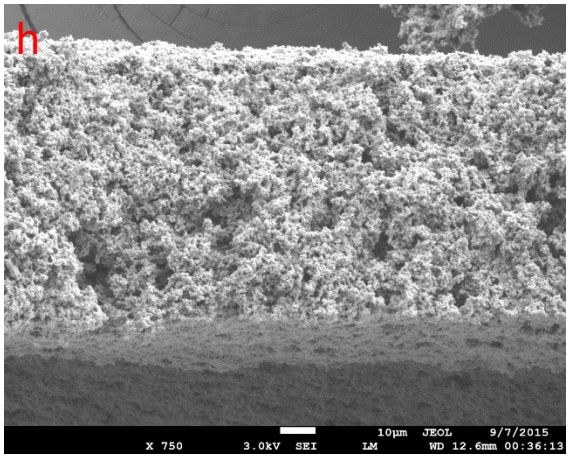
h
10µm JEOL 9/7/2015
X 750 3.0kV SEI LM WD 12.6mm 00:36:13

Supporting information 3: dq/dv vs. voltage curve for Ge asymmetric membrane of 100 μm wet thickness that were carbonized at 800 °C for 2 hrs during the first three formation cycles.