Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Flexible All Inorganic Nanowire Bilayer Mesh as a High-Performance Lithium-Ion Battery Anode

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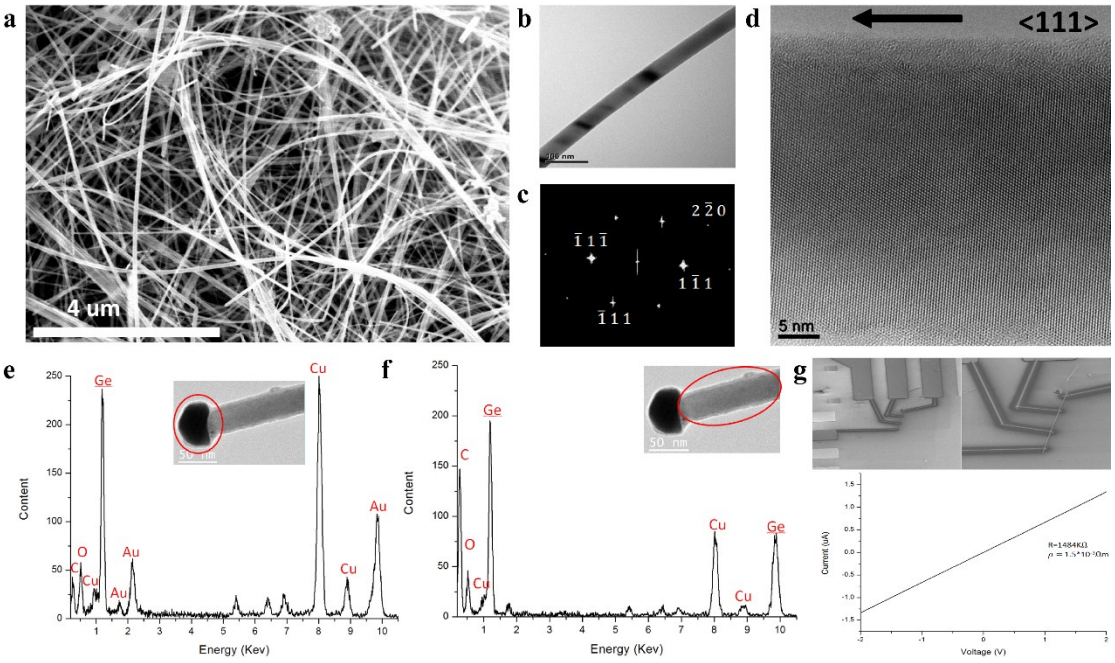

Fig. S1 Analysis of germanium nanowires. (a) SEM image of germanium nanowires (b) TEM image of germanium nanowires (c) Fast Fourier transform (FFT) pattern of (d). (d) HRTEM image of germanium crystalline nanowire. Most of the germanium nanowires grow along the <111> direction. (e) EDS analysis of the tip of the germanium nanowire. (f) EDS analysis of the stem of the germanium nanowire (g) Current–voltage characteristic of the single germanium nanowire. The resistivity of the single germanium nanowire is $1.5*10^{-3}$ Ω*m which is 300 times smaller than the bulk germanium ($4.6*10^{-1}$ Ω*m)[1].

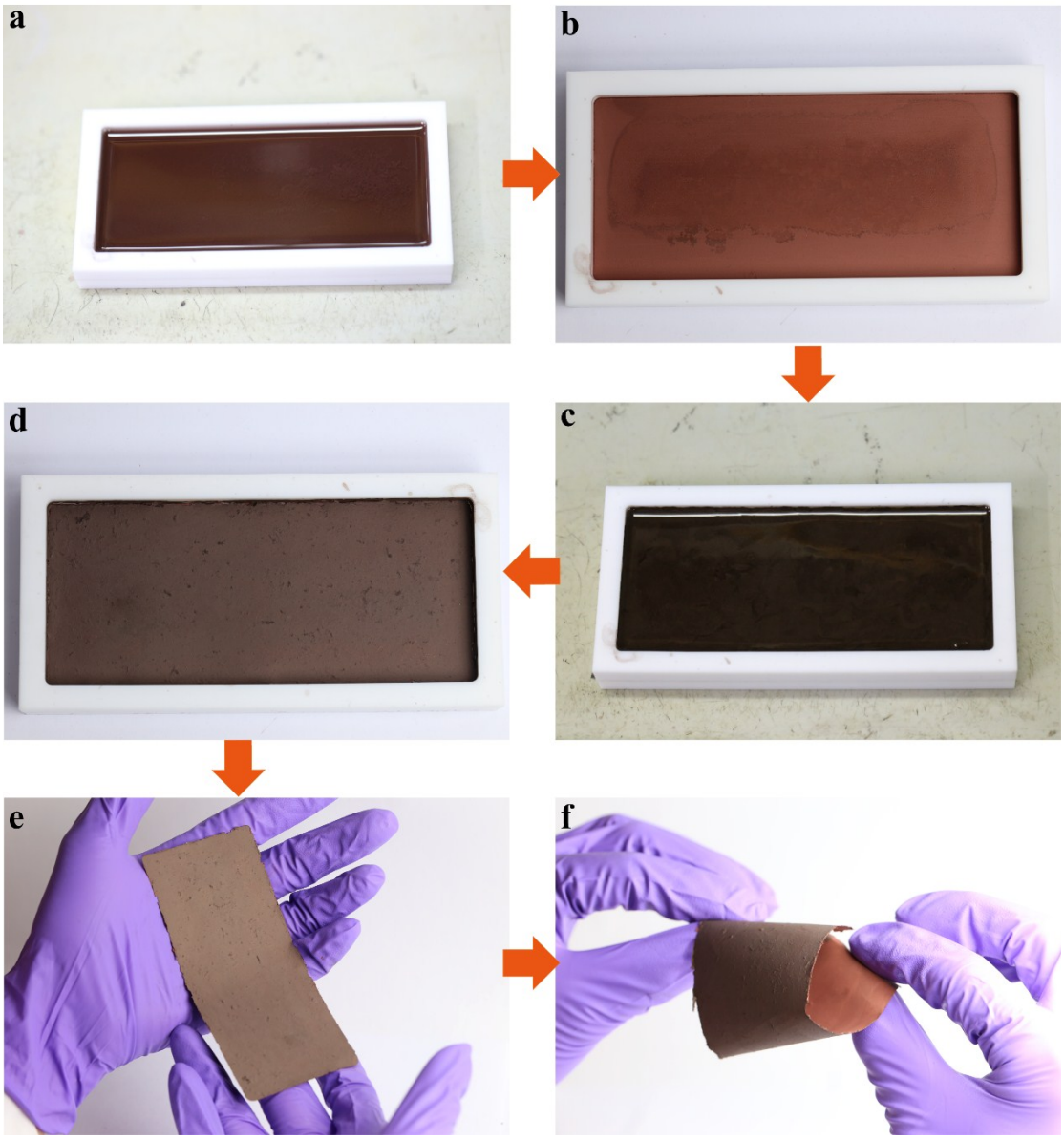

Fig. S2 Photographs of fabricating process of layered Ge/Cu nanowire mesh electrode. (a) The solution of copper nanowires was dropped into a PTFE mold. (b) Dried Cu nanowire mesh, the toluene fully evaporated. (c) The solution of germanium nanowires was then dropped onto the copper nanowires in PTFE mold. (d) Dried Ge/Cu nanowire mesh electrode, the toluene fully evaporated. (e), (f) The flexible

Ge/Cu nanowire mesh electrode was peeled form the PTFE mold and tailored to adequate size for following electrochemical test or other analysis.

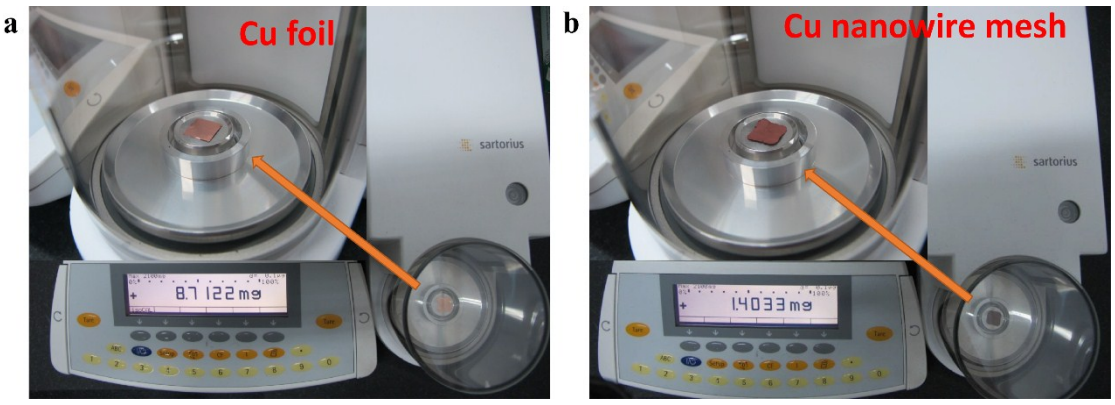

Fig. S3 Photographs of the mass of (a) Cu foil and (b) Cu nanowire mesh.

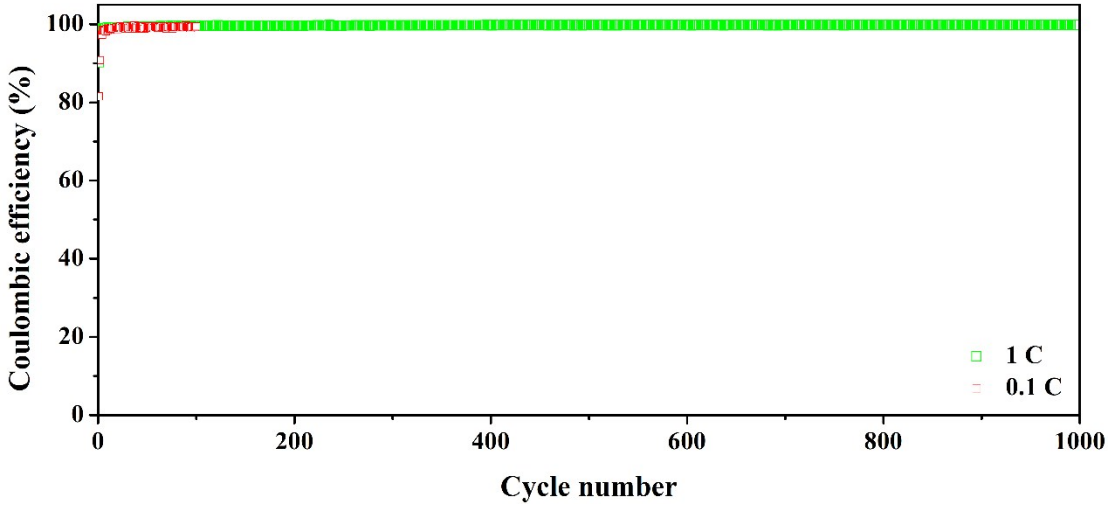

Fig. S4 Coulombic efficiency of layered Ge/Cu nanowire mesh electrode at the rate of 0.1 C and 1 C with FEC/DEC electrolyte.

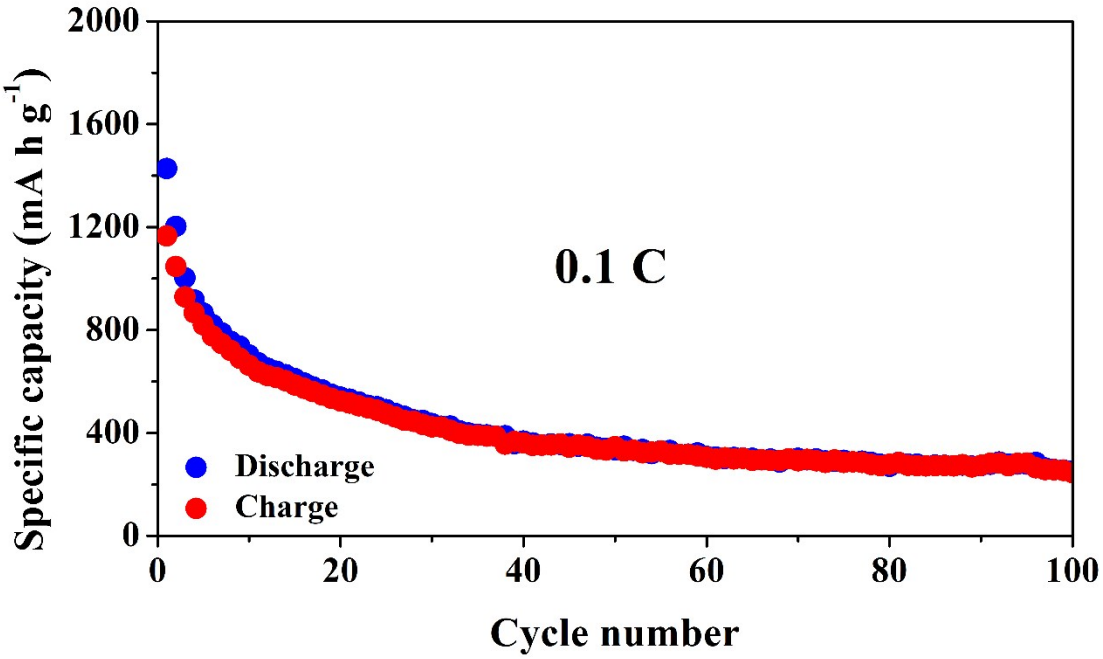

Fig. S5 Cycling performance of the Ge nanowire mesh/Cu foil electrode at a rate of 0.1 C.

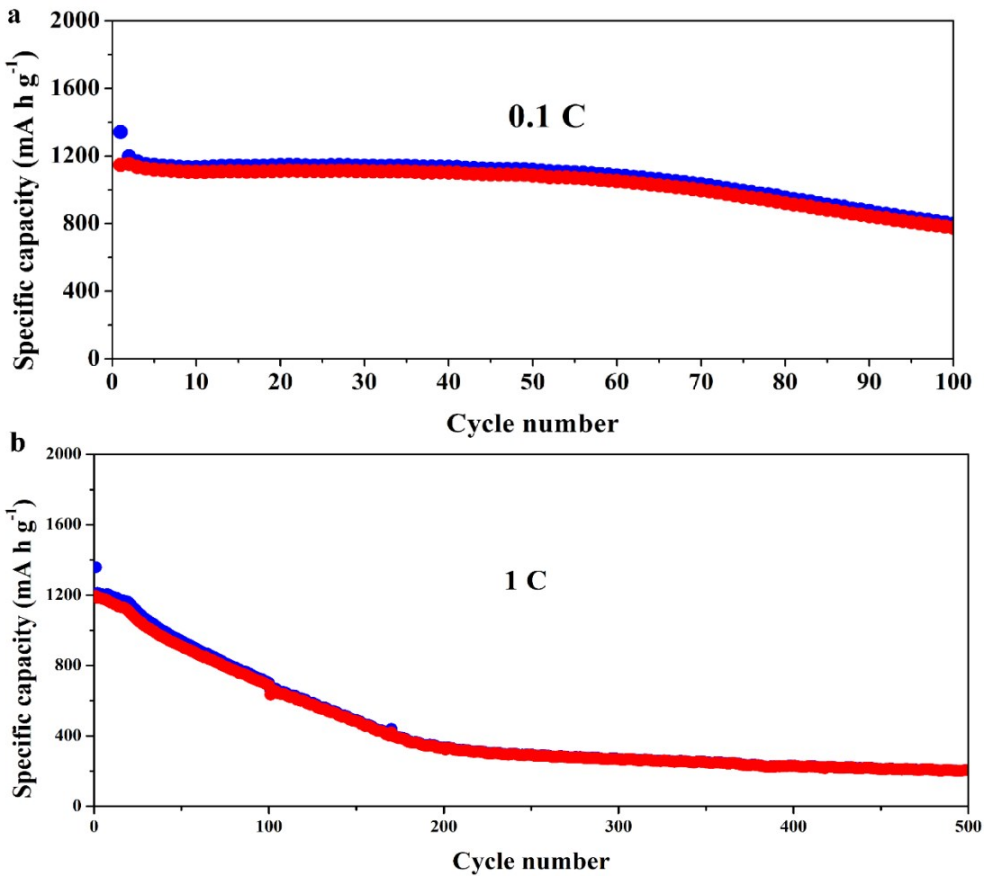

Fig. S6 Cycling performance of the Ge/Cu nanowire mesh electrode with EC/DMC electrolyte. (a) 0.1 C. (b) 1 C.

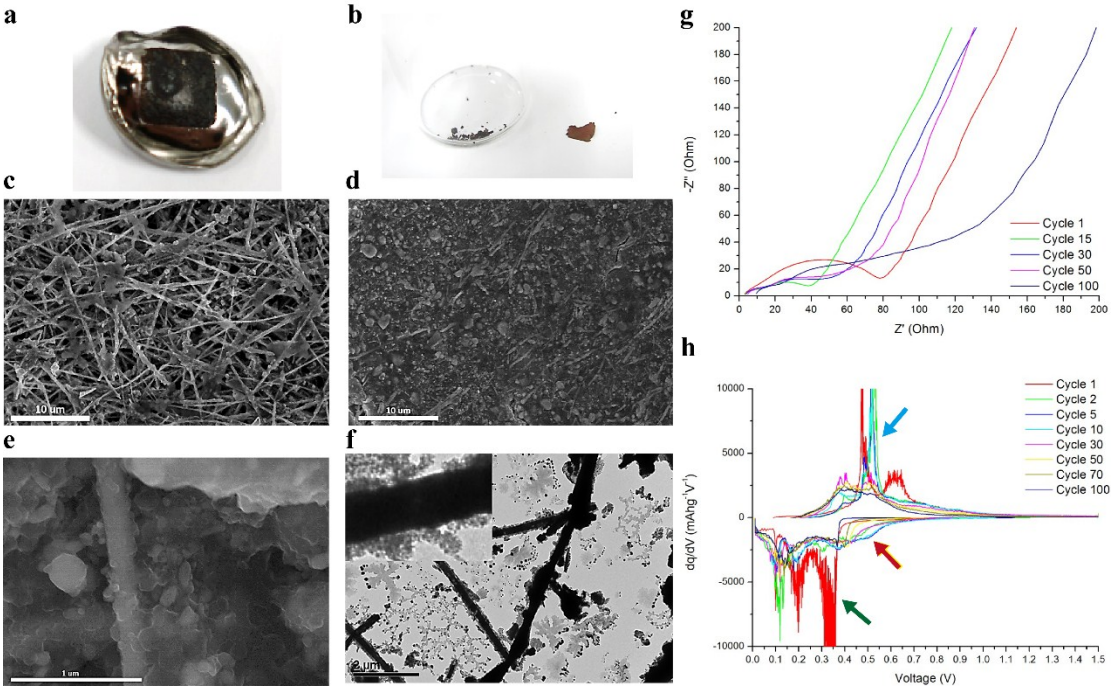

Fig. S7 Analysis of layered Ge/Cu nanowire mesh electrode after 200 cycles at a rate of 1 C with EC/DMC electrolyte. (a) Photograph of disassembling CR2032 coin cell. (b) Photograph of the fragments of Ge/Cu nanowire mesh electrode. Ge/Cu nanowire mash electrode was hard to peel from coin cell. (c) SEM image of Cu layer of layered Ge/Cu nanowire mesh electrode. (d) SEM image of Ge layer of Ge/Cu nanowire mesh

electrode. Most of the germanium nanowires were cracked and covered with thick SEI layer (e) High magnification SEM image of germanium nanowires. (f) TEM image of germanium nanowires. The inset image shows the germanium nanowire with incompact SEI layer. (g) Nyquist plots of layered Ge/Cu nanowire mesh electrode half-cell after various cycle 1^{st}, 15^{th}, 30^{th}, 50^{th}, 100^{th} at a rate of 1 C (1^{st} cycle at a rate of 0.1 C). (h) Differential capacity profile of layered Ge/Cu nanowire mesh electrode with the initial cycle at a rate of 0.1 C and the remaining 99 cycles at a rate of 1 C. The green arrow points out the first cycle. The red and blue arrow point out the gradually inward curve, which means the continuous fading of the cell.

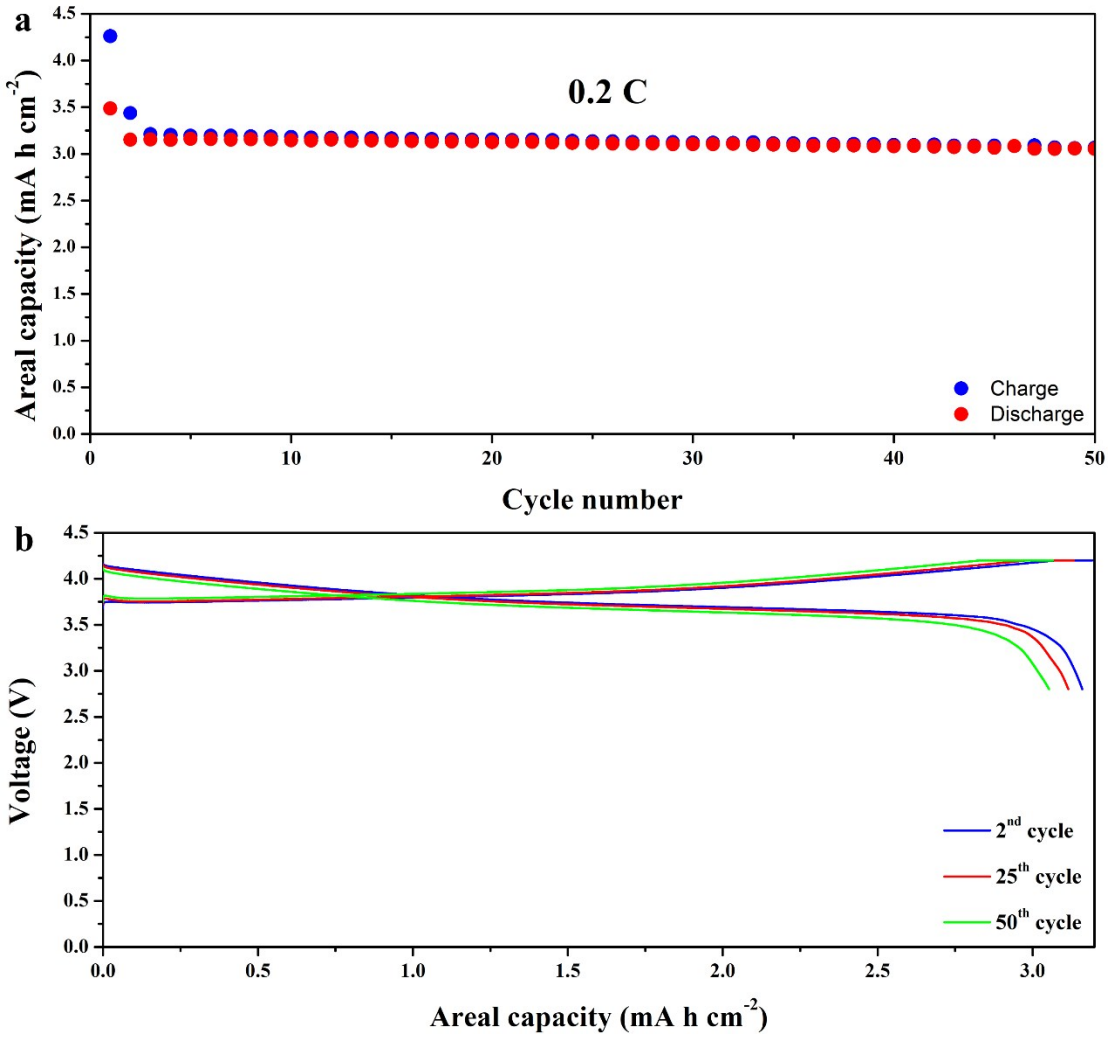

Fig. S8 Half-cell test of commercial $Li(Ni_{0.5}Co_{0.3}Mn_{0.2})O_2$ cathode (a) Cycling performance. (b) Voltage profile corresponding (a) 1 C = 160 mA g^{-1}.

Table S1 Comparison of bilayer Ge/Cu nanowire mesh electrode and conventional slurry-coating Ge nanomaterial electrodes.

Materials	Gravimetric Capacity (only	Loading mass (mg cm^{-2})	Current rate	Cycle	Gravimetric Capacity	Ref.

	active materials mA h g^{-1})	(include binder, conductivity agent)			(mA h g^{-1}) (whole electrode)	
Ge/Cu mesh	**832**	**0.5**	**1 C**	**1000**	**208**	
Graphite* **	**330**	**12.012**	**1 C**	**1000**	**193**	
Ge NWs	**940**	**1**	**1 C**	**50**	**72**	[2]
Ge NPS	**1152**	**0.5**	**1 C**	**200**	**37**	[3]
Ge NWs	**600***	**1**	**1 C**	**300**	**64**	[4]
Ge NTs	**765**	**1****	**1 C**	**10**	**63**	[5]
Gr/Ge NWs	**1150***	**1-1.9**	**1 C**	**200**	**115**	[6]
Ge/RGO/C	**993**	**0.6**	**1 C**	**600**	**48.**	[7]
3D porous Ge	**1415**	**1****	**1 C**	**100**	**116**	[8]
C-Ge/C	**896**	**1**	**1 C**	**120**	**73**	[9]
Sn-Ge	**990**	**0.5**	**1 C**	**100**	**34**	[10]
Ge NPs	**1100**	**1****	**0.8 C**	**40**	**90**	[11]
Ge@C/RGO	**800***	**1****	**0.9 C**	**40**	**70**	[12]
Ge VNWs	**550**	**1****	**0.8 C**	**30**	**45**	[13]
Ge/C	**736**	**1**	**0.1 C**	**20**	**60**	[14]
Ge NWs	**660***	**0.75 ****	**0.5 C**	**100**	**41**	[15]
Ge NPs	**789**	**1****	**0.15 C**	**20**	**65**	[16]
Ge/Cu_3Ge/C	**530**	**1****	**0.1 C**	**50**	**38**	[17]

*The estimation of graphs of literatures.

**The literature does not provide the loading mass; we assume that the loading mass is 1 mg cm^{-2}.

*** Assume the areal capacity of graphite is 4 mA h cm^{-2} and the reversible capacity is 330 mA h g^{-1}.

Table S2 Comparison of bilayer Ge/Cu nanowire mesh electrode and conventional slurry-coating Si nanomaterial electrodes.

Materials	Gravimetric Capacity (mA h g^{-1}) (only active materials)	Loading mass (mg cm^{-2}) (include binder, conductivity agent)	Current rate	Cycle	Gravimetric Capacity (mA h g^{-1}) (whole electrode)	Ref.
Ge/Cu mesh	**832**	**0.5**	**1 C**	**1000**	**208**	
Graphite* **	**330**	**12.012**	**1**	**1000**	**193**	
Si NWs	**1800**	**1**	**0.1 C**	**100**	**129**	[18]
Si NPs	**2600**	**0.5**	**0.2 C**	**100**	**56**	[19]
Si NWs	**1500**	**0.2 (Si)**	**0.05 C**	**30**	**33**	[20]
Si NPs	**1500***	**1****	**1 C**	**500**	**100**	[21]
Si fabric	**804**	**1****	**0.05 C**	**20**	**82**	[22]
Si NPs	**1250***	**1****	**0.5 C**	**100**	**90**	[23]
Si NPs	**1160**	**0.2 (Si)**	**0.5 C**	**1000**	**25**	[24]
Si NWs	**1300***	**0.1 (Si)**	**0.5 C**	**800**	**14**	[25]
Si MPs	**1750**	**0.7 (Si)**	**0.1 C**	**130**	**125**	[26]
Si NPs	**1600***	**0.3 (Si)**	**0.3 C**	**500**	**52**	[27]
Si NPs	**2200**	**0.2 (Si)**	**0.2 C**	**100**	**48**	[28]

*The estimation of graphs of literatures.

**The literature does not provide the loading mass; we assume that the loading weight is 1 mg cm^{-2}.

*** Assume the areal capacity of graphite is 4 mA h cm^{-2} and reversible capacity is 330 mA h g^{-1}.

Table S3 Loading mass and volumetric capacities of graphite, Ge/Cu nanowire mesh and other Ge flexible electrodes.

	Loading mass of active materials (mg cm^{-2})	Thickness of Cu (μm)	Thickness of active materials (μm)	Thickness of whole electrodes (μm)	Volumetric capacity based on the total volume of whole electrode	Ref.

					(m Ah cm^{-3})	
Graphite	**4**	**10**	**146.6**	**156.6**	**255.3**	
Ge/Cu mesh	**0.5~6**	**15**	**8~96.3**	**23~111.3**	**217~539**	
Ge@CNFs	**0.291**	**-**	**-**	**500**	**5.82**	[29]
Ge@CNFs-2	**0.504**	**-**	**-**	**200**	**25.2**	[30]
Ge@Graphene	**1.32**	**-**	**-**	**-**	**-**	[31]
Ge@CNFs-3	**0.404**	**-**	**-**	**-**	**-**	[32]

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