Electronic Supplementary Information (ESI)

Improved performances of lithium-ion batteries with a separator based on inorganic fibers

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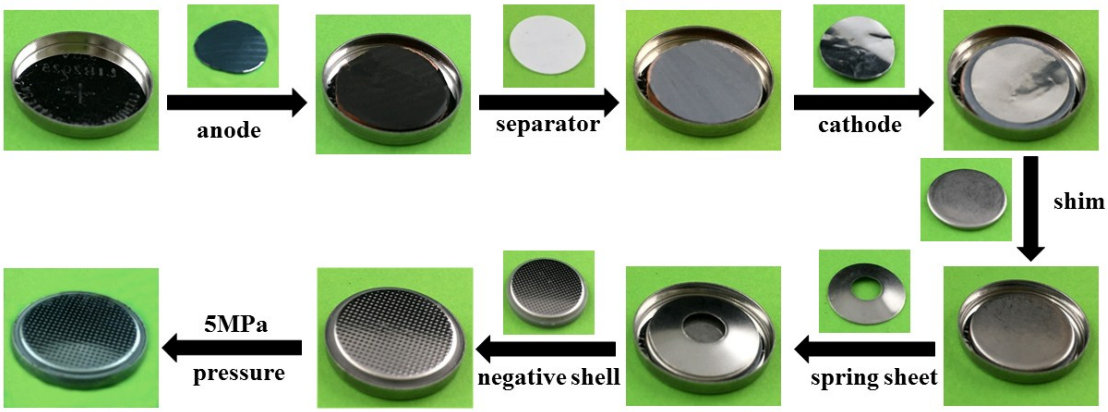

Fig. S1 Procedure of battery assembly: the cell (2025 type coin cell) was assembled in a glove box filled with argon (MB-200B-MOD, Germany). The anode ($Li(Ni_{1/3}Co_{1/3}Mn_{1/3})O_2$/PVDF/carbon black = 93/3/4, w/w/w), the separator and the cathode (graphite) were firstly cut into circular shape with the same diameter of 20 mm, after which they were dried at 80 ℃ in a vacuum oven for 24 h. The anode and the cathode were then employed with a liquid electrolyte containing 1 mol $LiPF_6$ and 1 L of solvent mixture of ethylene carbonate (EC)/dimethyl carbonate (DMC)/ethyl methyl carbonate (EMC) (1/1/1, v/v/v). The separator was wetted with the liquid electrolyte and located in between the cathode and anode, followed by overlapping the shim, the spring sheet and the negative shell in sequence. Finally, the components were pressed together under 5 MPa.

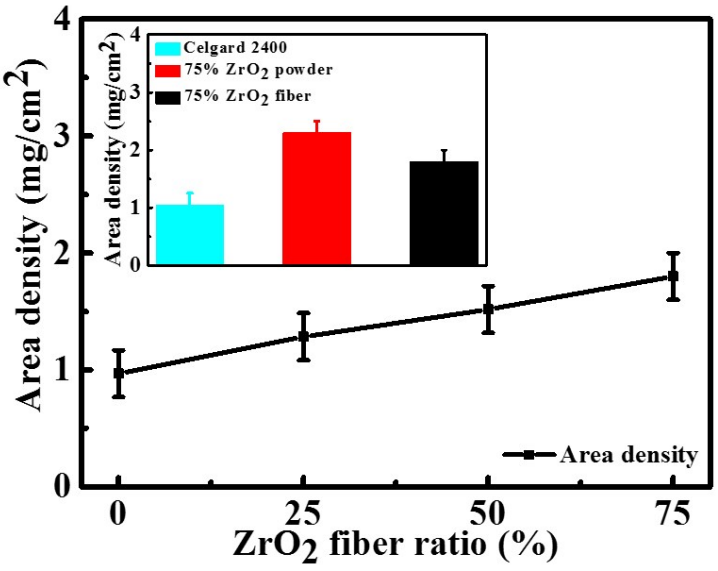

Fig. S2 Areal density of membranes containing 0, 25%, 50% and 75% ZrO_2 fibers, 75% ZrO_2 powders and Celgard 2400.

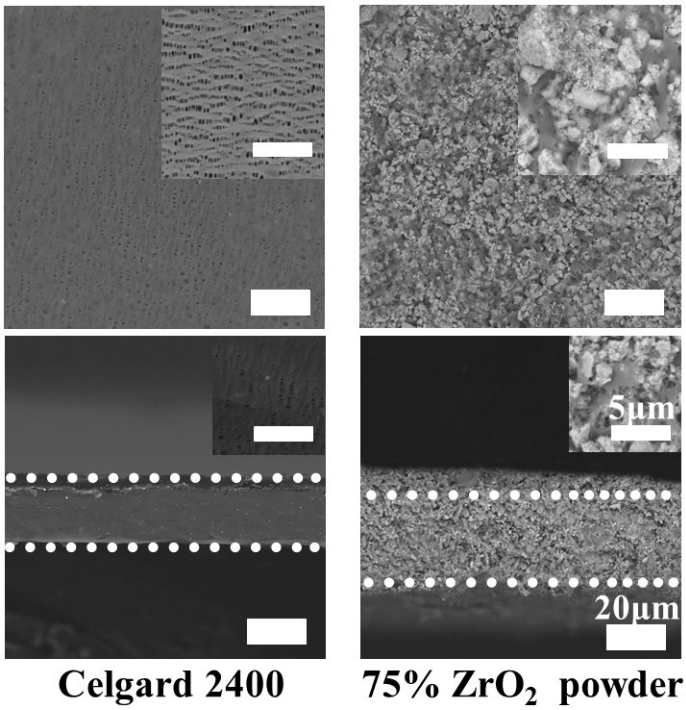

Fig. S3 Surface and cross-sectional SEM micrographs of Celgard 2400 and ZrO_2/PVDF-HFP membrane containing 75% ZrO_2 powders.

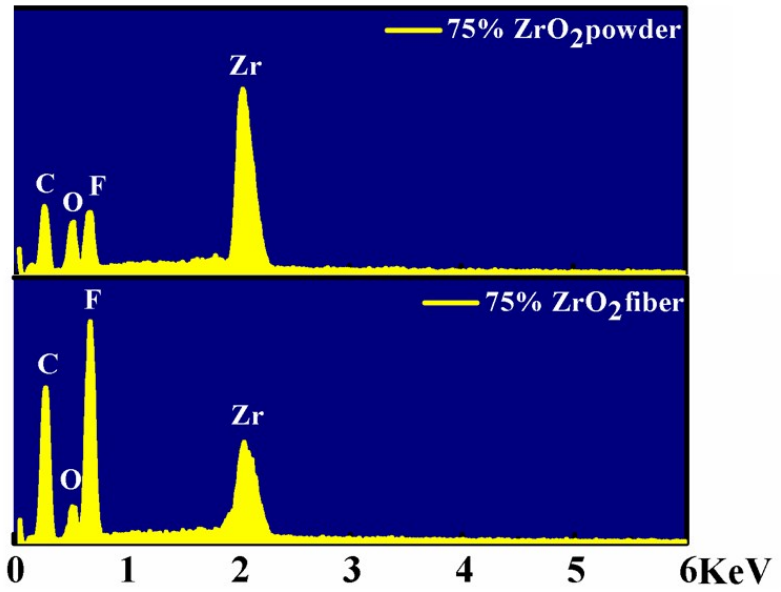

Fig. S4 EDX of membranes containing 75% ZrO_2 powder and 75% ZrO_2 fiber.

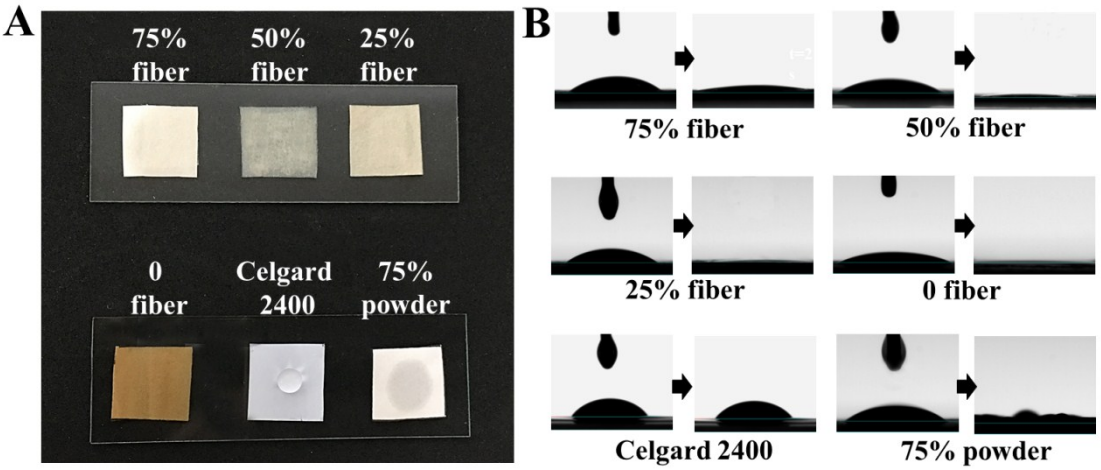

Fig. S5 A) The spreading behavior of an electrolyte droplet on membranes containing 0, 25%, 50% and 75% ZrO_2 fibers, Cellgard 2400 and membrane containing 75% ZrO_2 powders. B) Water contact angles of the membranes.

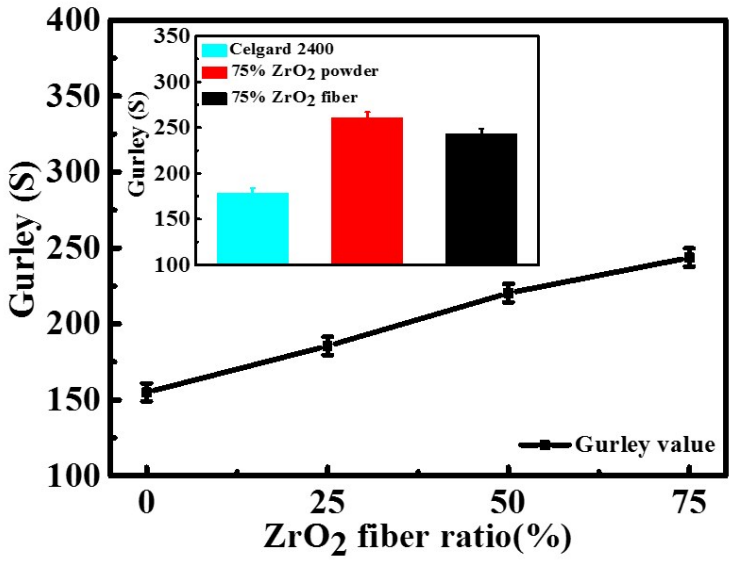

Fig. S6 The Gurley value of Celgard 2400, membranes containing 0, 25%, 50% and 75% ZrO_2 fibers, and membrane containing 75% ZrO_2 powders.

Table S1 The Li^+ diffusion coefficient and ionic conductivity of the cells based on Celgard 2400, 75% ZrO_2 powder separator and separators containing 0, 25%, 50% and 75% ZrO_2 fibers.

Cells	Celgard 2400	75% ZrO_2 powder	75% ZrO_2 fiber	50% ZrO_2 fiber	25% ZrO_2 fiber
Li^+ diffusion coefficient (cm/s)	4.45×10^{-12}	4.35×10^{-12}	4.42×10^{-12}	4.23×10^{-12}	4.55×10^{-12}
Ionic conductivity (mS/cm)	0.199	0.299	0.320	0.275	0.246

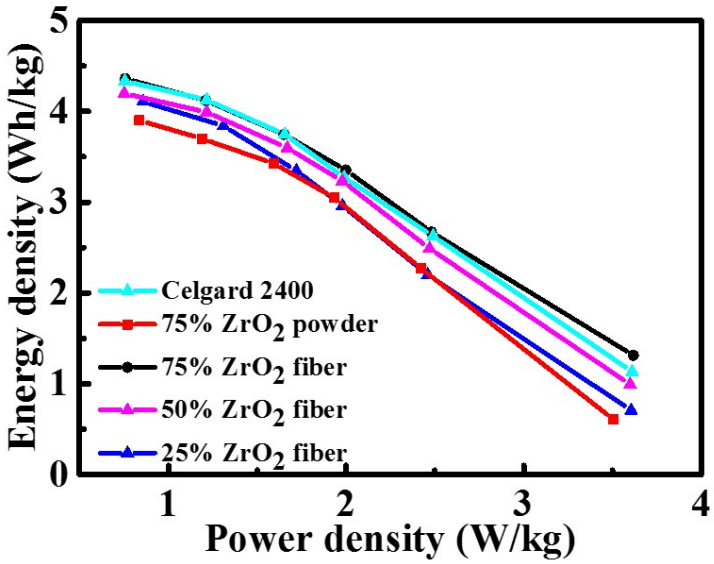

Fig. S7 The Ragone plots of cells based on Celgard 2400, separators containing 0, 25%, 50% and 75% ZrO_2 fibers, and separator containing 75% ZrO_2 powders.

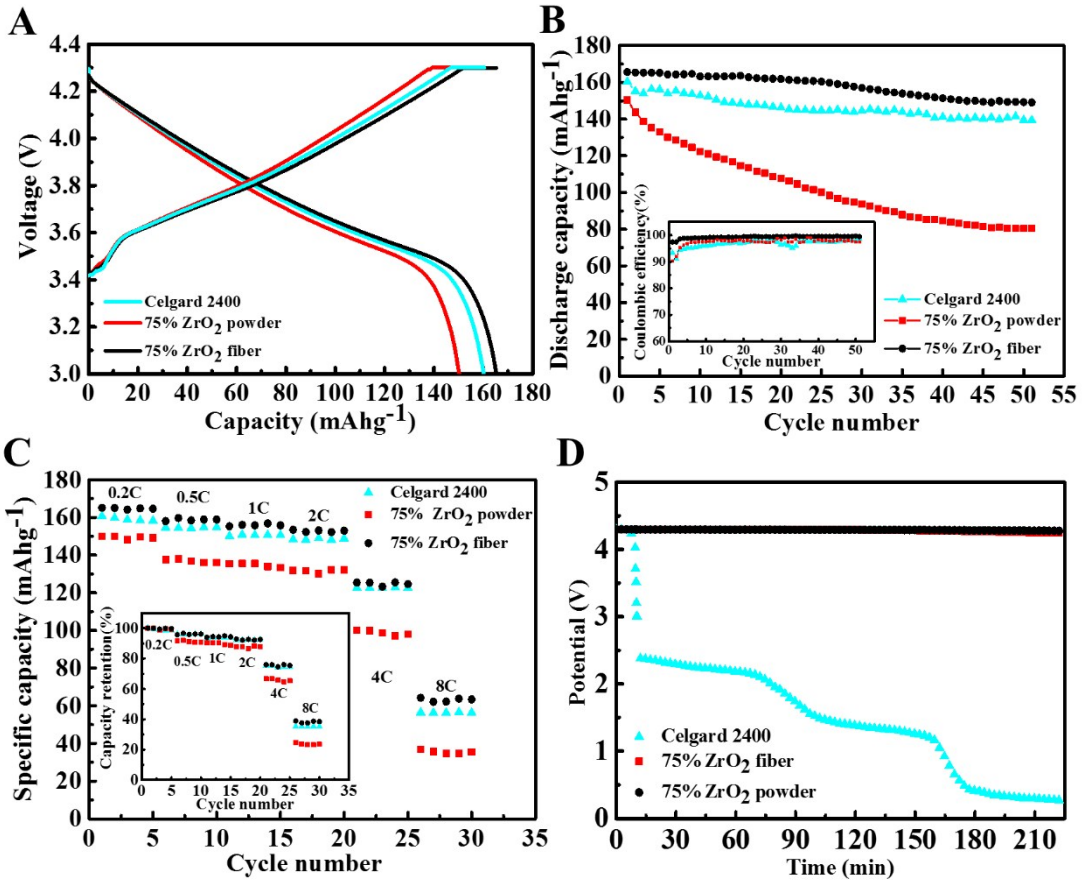

Fig. S8 Electrical properties and electrochemical performances of the cells composed of Celgard 2400, 75% ZrO_2 powder and 75% ZrO_2 fiber separators at elevated temperature. A) First Charge/discharge curves, B) cycle performance at cut-off voltage range from 3.0 to 4.3 V and a current rate of 0.2 C at 60 ℃, C) rate capability under charge/discharge rates from 0.2 to 8 C at 60 ℃, and D) The OCV changes of the unit cells exposed at 140 ℃.

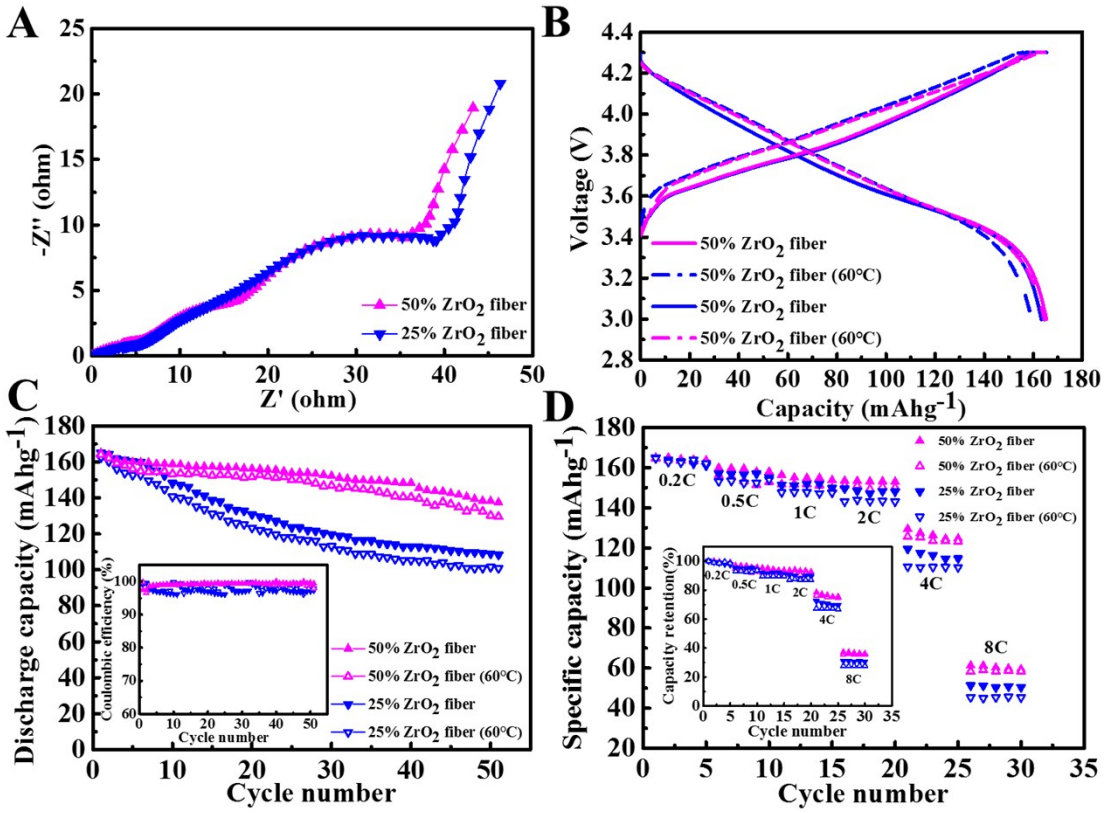

Fig. S9 Electrical properties and electrochemical performances of the cells based on 25% and 50% ZrO_2 fiber separators. A) EIS profiles at room temperature, B) first charge/discharge curves, C) cycle performance at cut-off voltage range from 3.0 to 4.3 V and a current rate of 0.2 C at 60 ℃, and D) rate capability under charge/discharge rates from 0.2 to 8 C at room temperature and at 60 ℃.