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Supplementary material

In-situ Hyperconnective Network Strategy to Prepare Lanthanum Zirconate Nanofibers Membrane with Superior Flexibility and Toughness

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Table S1 Conductivity & Viscosity of Precursor Sol.

	σ (mS/cm)	η (mPa·s)
$La_2Zr_2O_7$ (LZO)	14.27	89.6
$La_{1.91}Zr_2Al_{0.09}O_7$ (L3AZO)	15.62	88.4
$La_{1.85}Zr_2Al_{0.15}O_7$ (L5AZO)	15.91	92.6
$La_{1.79}Zr_2Al_{0.21}O_7$ (L7AZO)	17.99	106.0

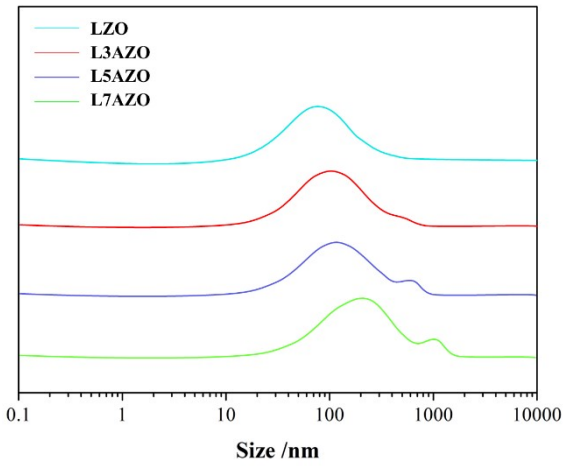

Fig. S1 Particle size distribution of various LZO and LAZO precursor sol.

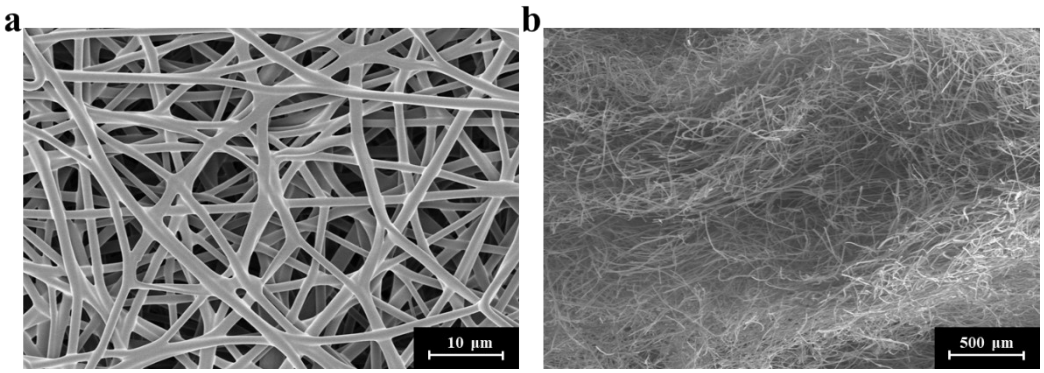

Fig. S2 Anisotropic L5AZO NFM: (a) Parallel collector; (b) Vertical collector.

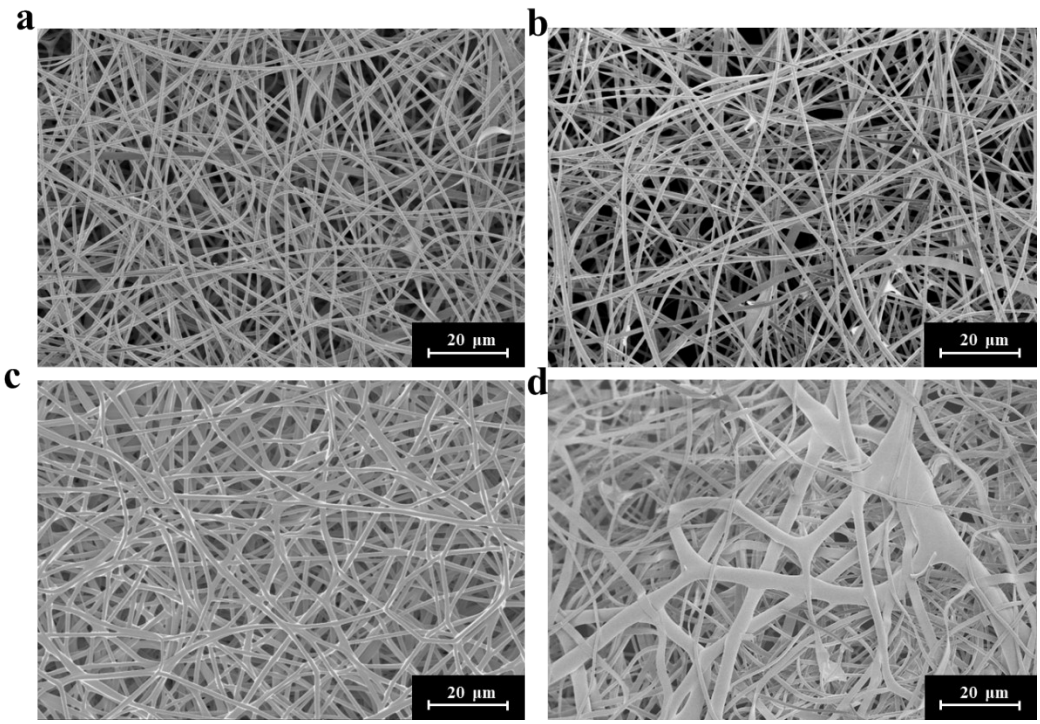

Fig. S3 SEM images of LZO and LAZO as-spun nanofibers membrane: (a) LZO; (b) L3AZO; (c) L5AZO; (d) L7AZO.

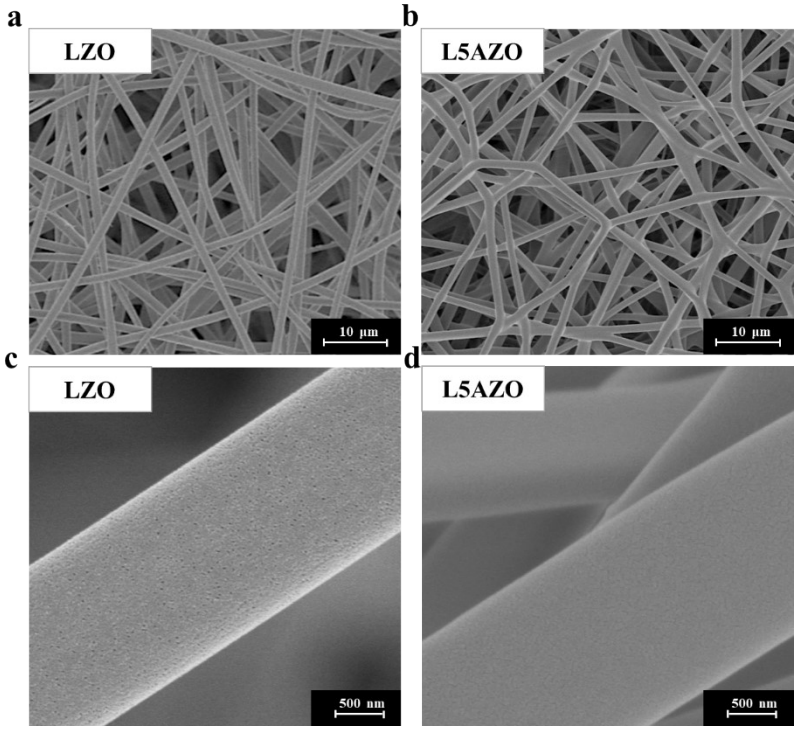

Fig. S4 SEM images of LZO and L5AZO NFM pre-treated at 200 °C: (a, c) LZO; (b, d) L5AZO.

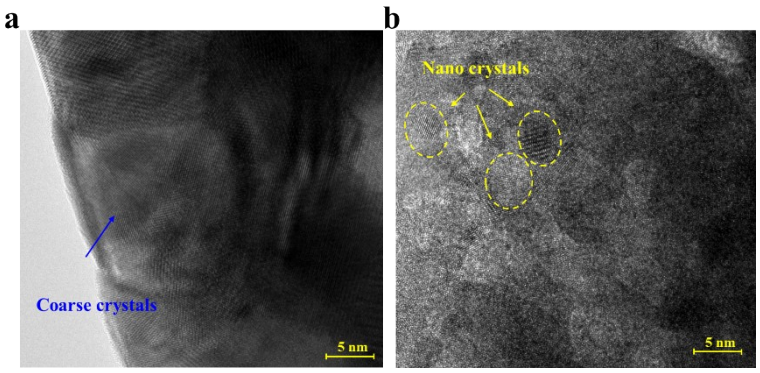

Fig. S5 HRTEM images of a) LZO and b) L5AZO nanofibers membrane after calcining at 900 °C.

We established a finite element model based on the microscopic image of the NFM, and analyzed its normal form equivalent stress and damage mechanism during uniaxial tension. In the tensile process, the NFM network is oriented under the action of load, and the stress component in the tensile direction on the fiber skeleton gradually increases, which corresponds to the increase of the tangent modulus of the stress-strain curve. It can be seen from the stress nephogram under different strains that the fiber lap joint bears the main stress tensor, so the first stage of the process from strain to damage of the fiber membrane is the failure of the NFM network node. When the strain is further increased, the damage of the fiber membrane gradually extends from the node to its skeleton. At this time, the fiber membrane produces a yield phenomenon, leading to a decline in its load capacity, which means that the fiber membrane enters the molding deformation stage at this time.

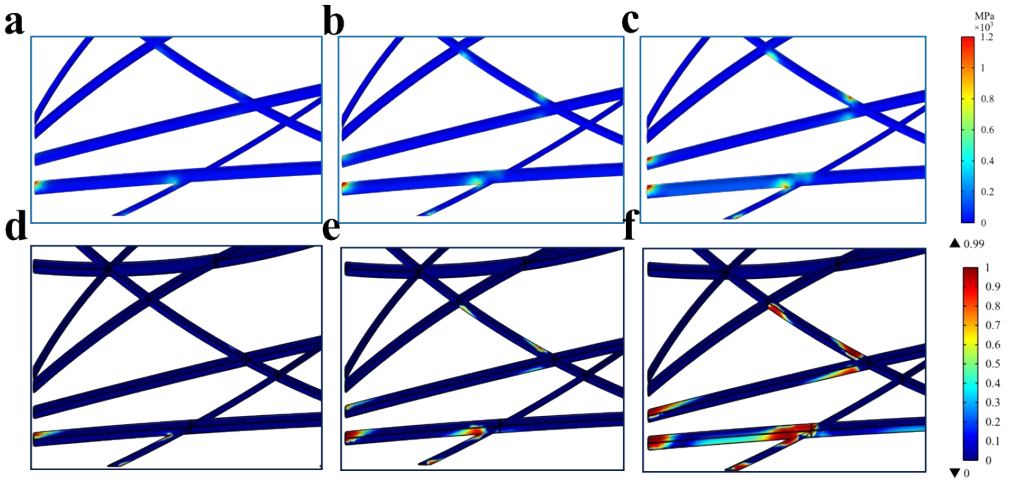

Fig. S6 Theoretical stimulation. a-c) A 2D network representing strain (0.2%, 1.0%, 3%) and stress of NFM with various connectivity. d-f) A 2D network representing stress concentration of NFM with various strain (strain 0.2%, 1.0%, 3%).

Table S2 Density & Viscosity of sintered NFM (900 °C).

	Apparent density (g/cm^3)	Density (g/cm^3)	Volume Fraction (%)
LZO	0.14	2.98	4.7
L5AZO	0.17	3.04	5.6

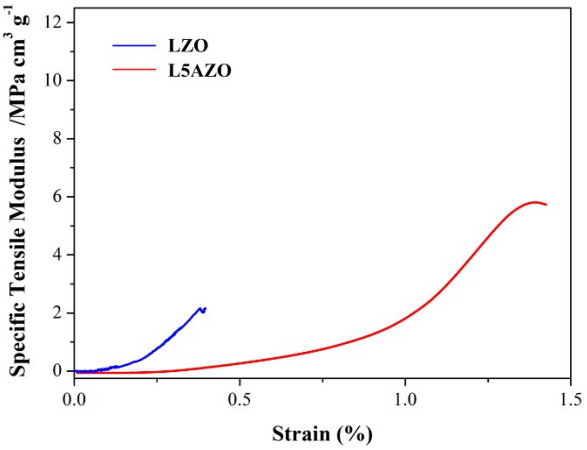

Fig. S7 The specific tensile modulus of L5AZO NFM (900 °C).

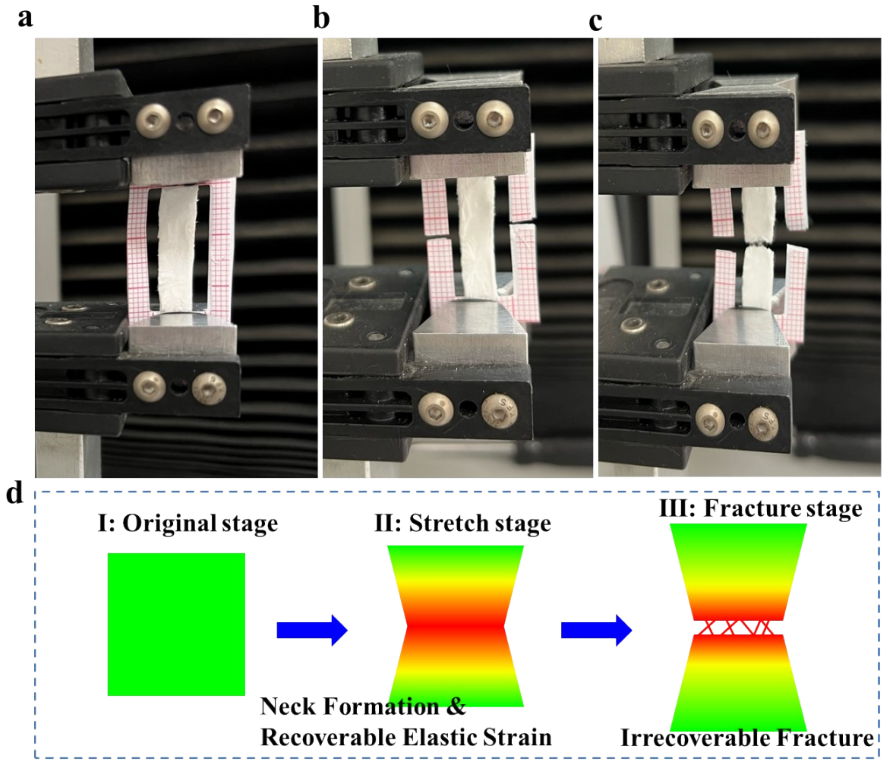

Fig. S8 a-c) Dynamic tensile behavior of L5AZO NFM after firing at 900 °C. d) The illustration of Neck formation and Mechanical characteristics of L5AZO NFM.

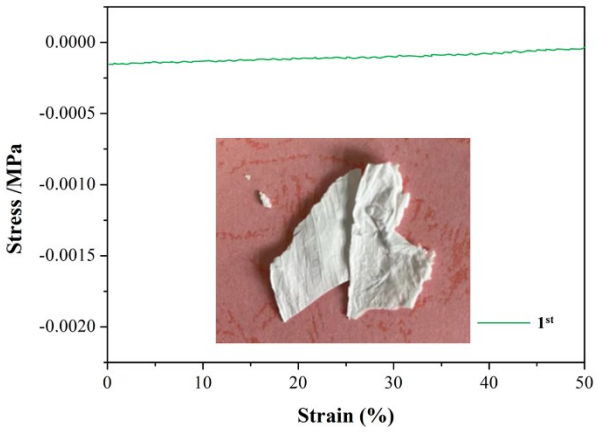

Fig. S9 Dynamic tensile behavior of LZO NFM after firing at 900 °C.