

Supplementary Information

Constructing Electrospun 3D Liquid Metal Adhesion Channel on Stretchable Yarns for Broad-Range Strain-Insensitivity Smart Textiles

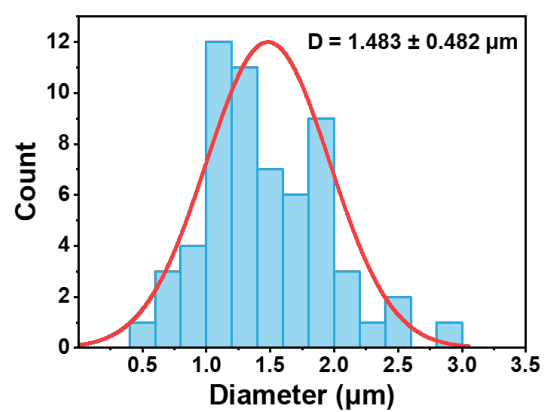
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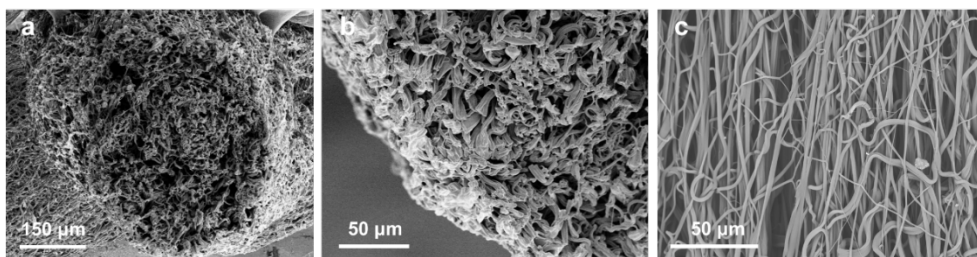
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Supplementary Table 1. Comparison of electrical performance among the currently reported liquid metal-based stretchable conductive yarns.

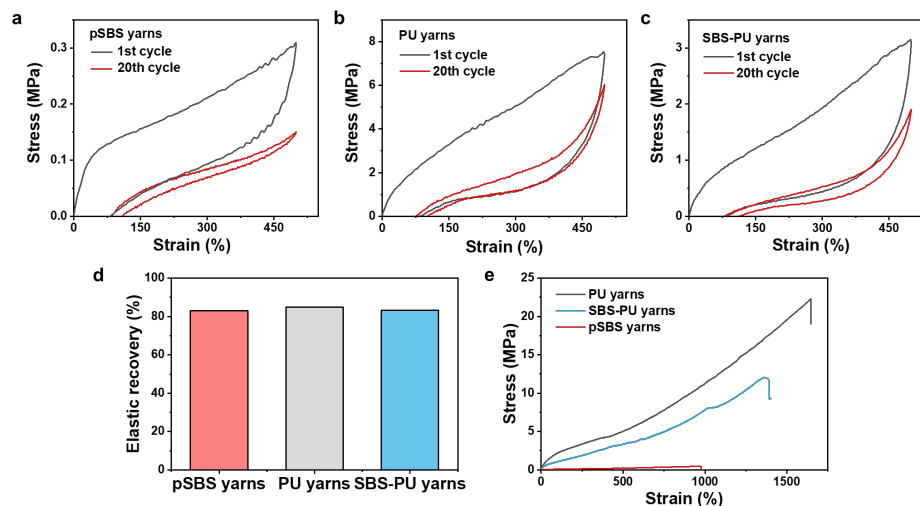
Strategy	Low initial resistance	Conductivity stability under large strain	Conductivity stability under long-term cyclic strain
Coating liquid metal on fiber ¹⁻⁵	√	X	X
Liquid metal in tube ⁶⁻⁹	√	X	X
Liquid metal particle treated yarn ¹⁰⁻¹²	X	√	X
LM three-dimensional adhesion channel structure (This work)	√	√	√



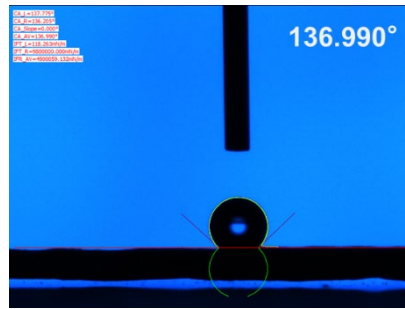
Supplementary Figure 1. Diameter distribution of pristine SBS microfibers analyzed by SEM images.



Supplementary Figure 2. SEM of pure electrospun SBS microfiber yarns (pSBS yarns). **a-b** Cross-sectional SEM image of pSBS yarns. **c** Surface morphology of pSBS yarns.



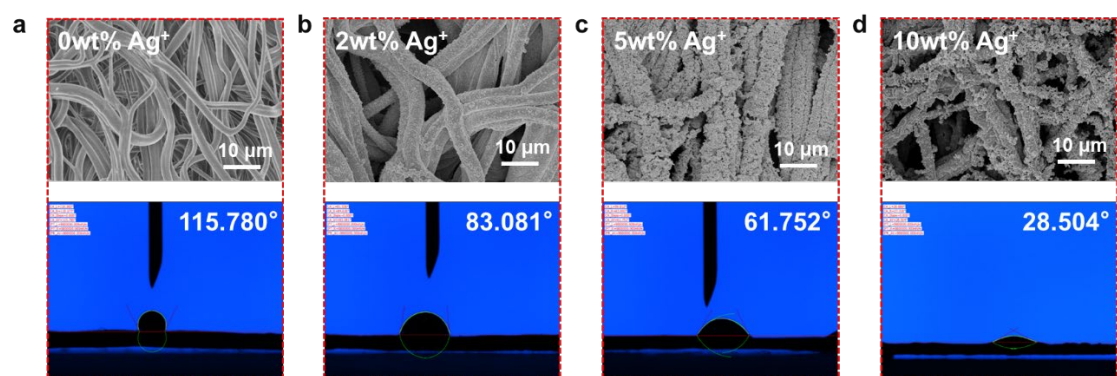
Supplementary Figure 3. **a** Cycling tensile curves of pSBS yarns at 500% strain (20 cycles). **b** Cycling tensile curves of PU yarns at 500% strain (20 cycles). **c** Cycling tensile curves of SBS-PU yarns at 500% strain (20 cycles). **d** Comparative diagram of elastic recovery of pSBS yarns, PU yarns and SBS-PU yarns after 20 tensile cycles. **e** Stress-strain curves of PU yarns, SBS-PU yarns and pSBS yarns.



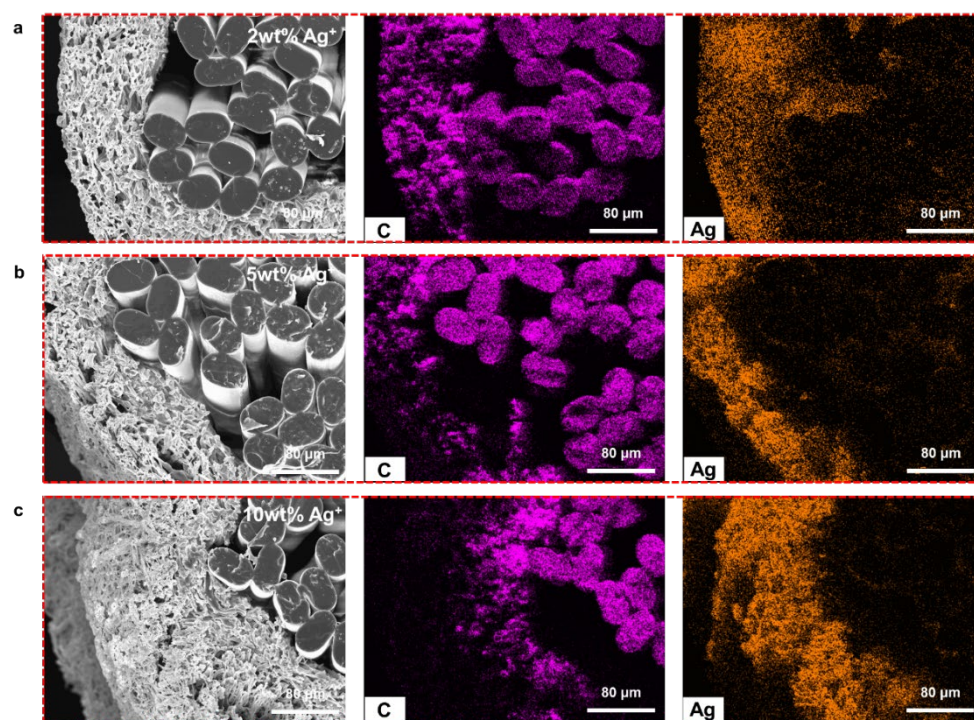
Supplementary Figure 4. Contact angle (CA) between SLMAS yarns and water, indicating that SLMAS yarns have excellent hydrophobicity.



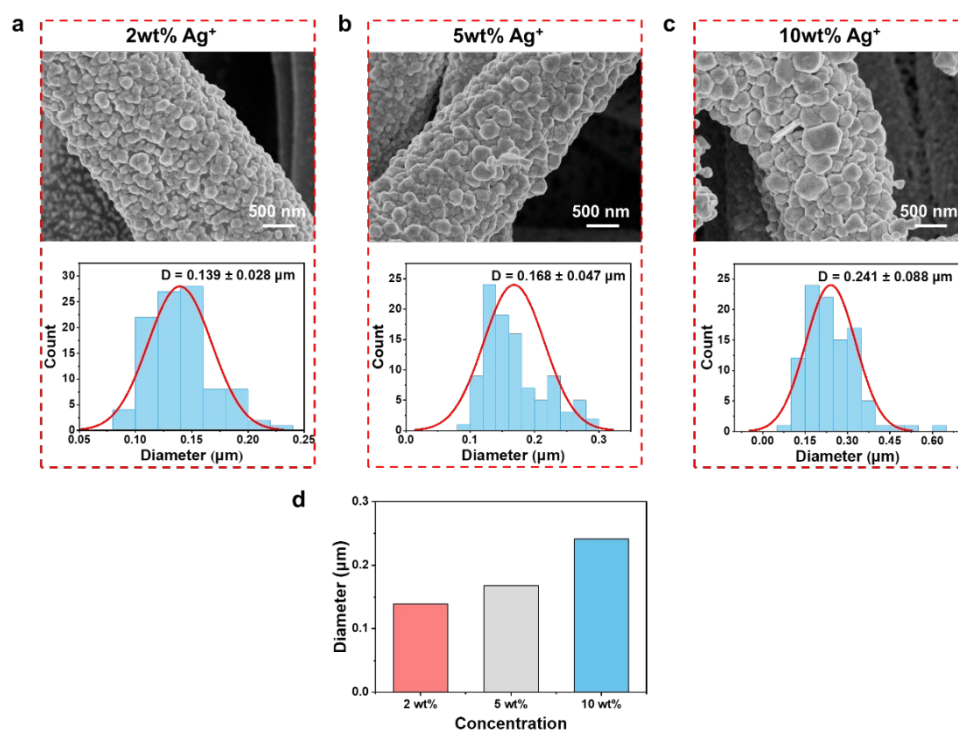
Supplementary Figure 5. **a-b** Photographs showing the weaving process of the conductive fabric, which is woven from commercial yarns and SLMAS yarns. **c** Photomicrograph of a conductive fabric woven from a mixture of commercial yarns and SLMAS yarns.



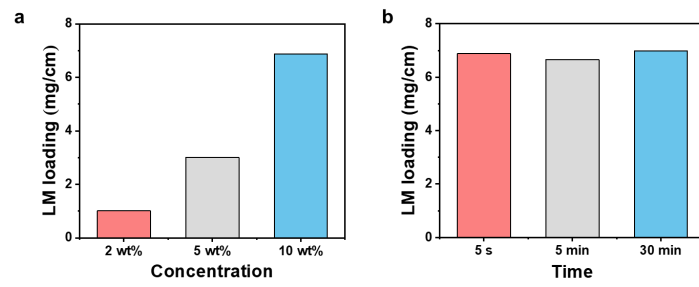
Supplementary Figure 6. High adhesion to LM by modulating the silver precursor concentration. The SEM images of SBS-PU yarns treated by different concentrations of silver precursor solutions (**a** 0wt%, **b** 2wt%, **c** 5wt%, **d** 10wt%) and the corresponding CA between yarns and LM.



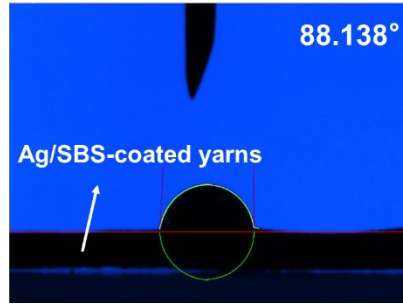
Supplementary Figure 7. Cross-sectional energy-dispersive X-ray spectroscopy (EDS) mapping of SBS-PU yarns treated by different concentrations of silver precursor solutions (**a** 2wt%, **b** 5wt%, **c** 10wt%).



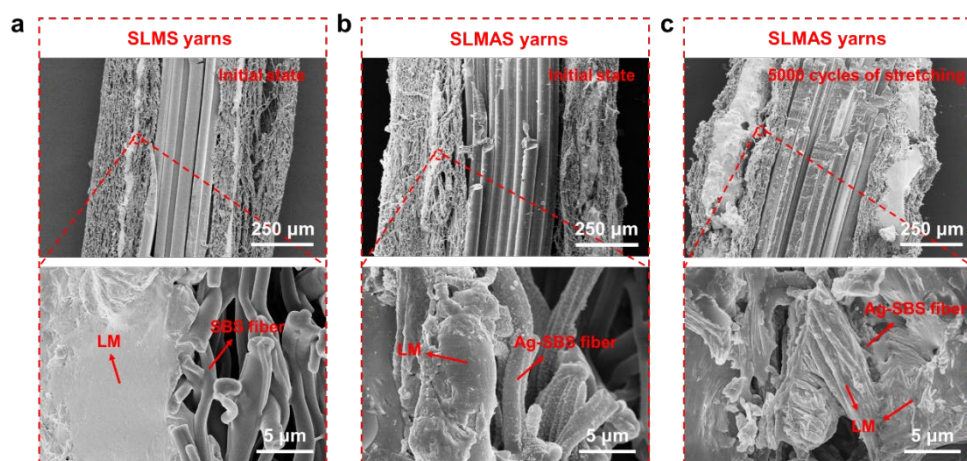
Supplementary Figure 8. **a-c** High magnification SEM images of SBS-PU yarns treated with different concentrations of silver precursor solutions (a 2wt%, b 5wt%, c 10wt%) and the corresponding Ag NPs diameter distribution curves. **d** Comparative chart of Ag NPs diameters treated with different concentrations of silver precursors.



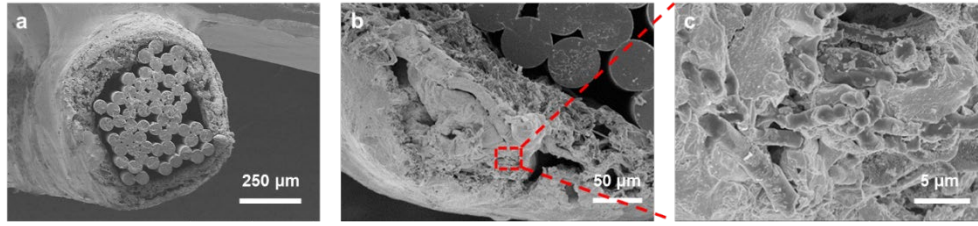
Supplementary Figure 9. **a** LM loading on yarns after treatment with different concentrations of silver precursor solutions. **b** LM loading on the yarns for different immersion time.



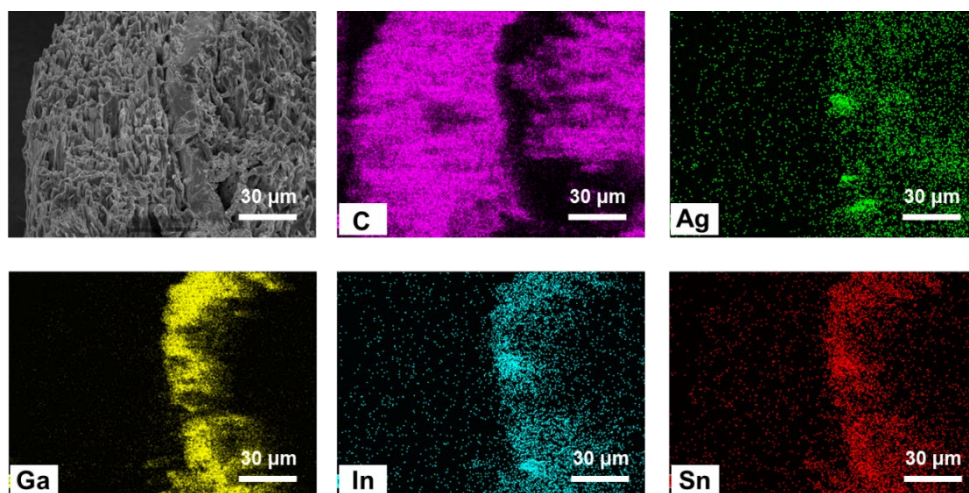
Supplementary Figure 10. The contact angle between LM and Ag modified SBS-coated yarns (Ag/SBS-coated yarns).



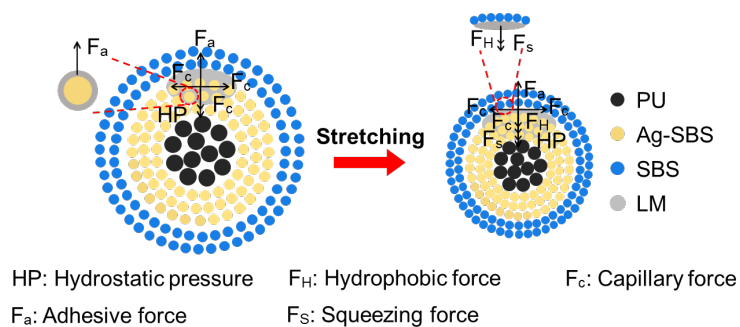
Supplementary Figure 11. **a** Longitudinal-sectional SEM image of SLMS yarns (yarns obtained by coating LM directly onto SBS-PU yarns and encapsulating them), showing that LM is distributed between fiber layers without being drawn into the fiber pores. **b** Longitudinal-sectional SEM image of SLMAS yarns, showing that LM is absorbed into the fiber pores and completely wraps around the fibers. **c** Longitudinal-sectional SEM image of SLMAS yarns after 5000 cycles of stretching (500% strain) showing the morphology of the LM firm coating on the surface of SBS fibers after cyclic stretching.



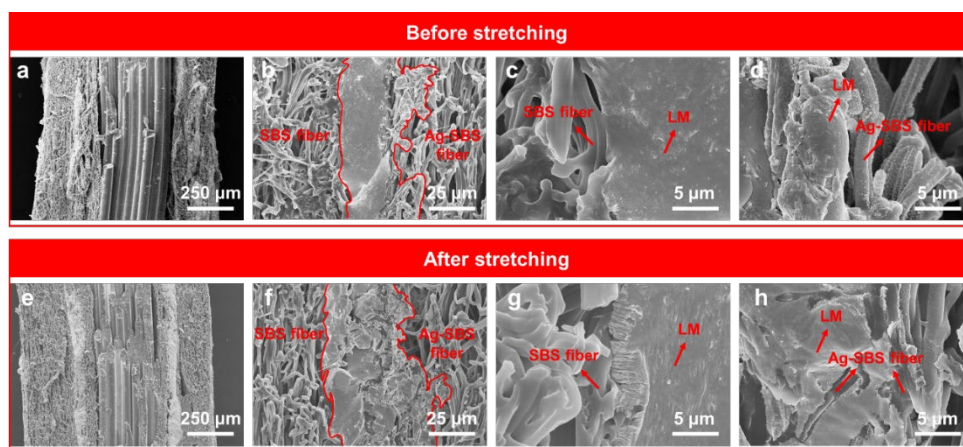
Supplementary Figure 12. a-c Cross-section SEM images of LMAS yarns at different magnifications.



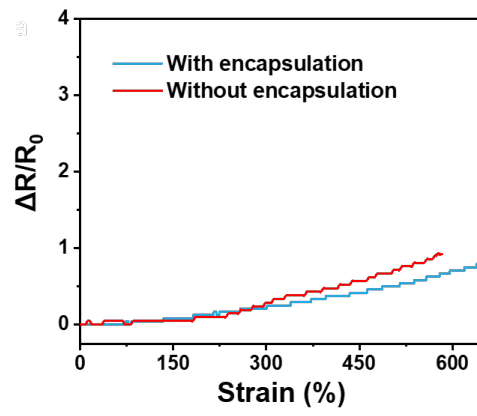
Supplementary Figure 13. Cross-sectional energy-dispersive X-ray spectroscopy (EDS) mapping of SLMAS yarns.



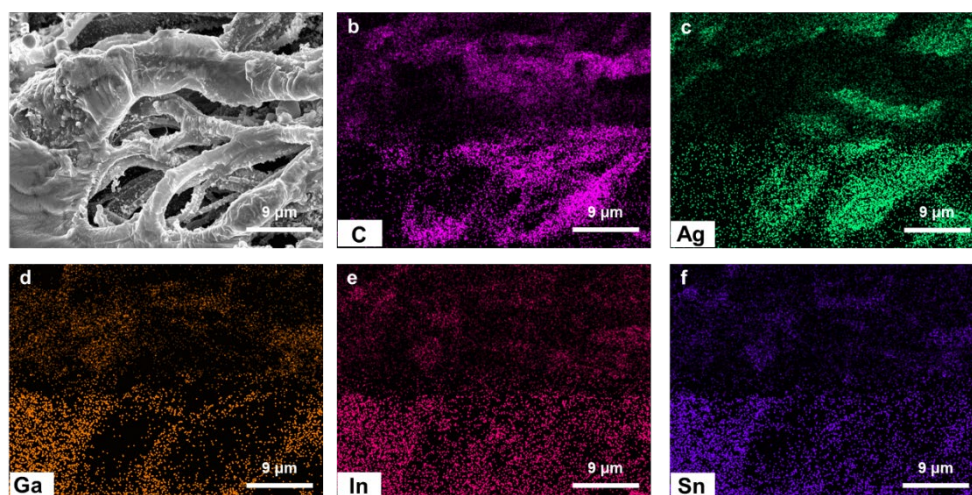
Supplementary Figure 14. Schematic of the mechanism by which the SBS fiber layer squeezes the LM under stretching, allowing more LM to immerse into the Ag-SBS fiber channel with higher wettability. The encapsulation layer compresses the LM during the stretching process, and at the same time, the LM is subject to reverse hydrophobic forces due to the non-wettability of the encapsulation layer.



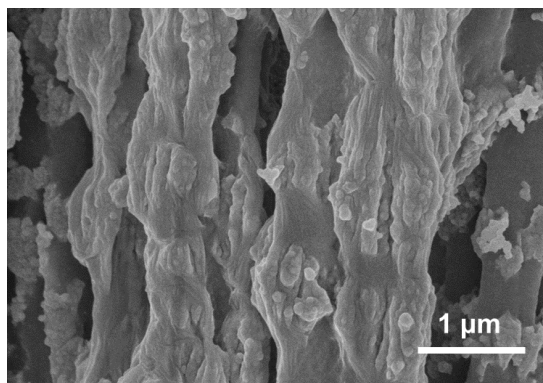
Supplementary Figure 15. **a-d** Longitudinal cross-section SEM images of SLMAS yarns at different magnifications showing the distribution of LM within the yarns. **e-h** Longitudinal cross-section SEM images of SLMAS yarns after stretching at different magnifications, showing variation in the distribution of LM.



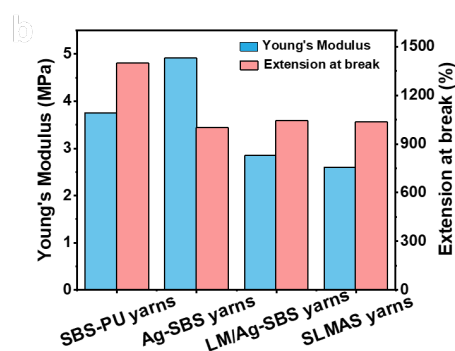
Supplementary Figure 16. Resistance changes of the yarns with encapsulation and without encapsulation.



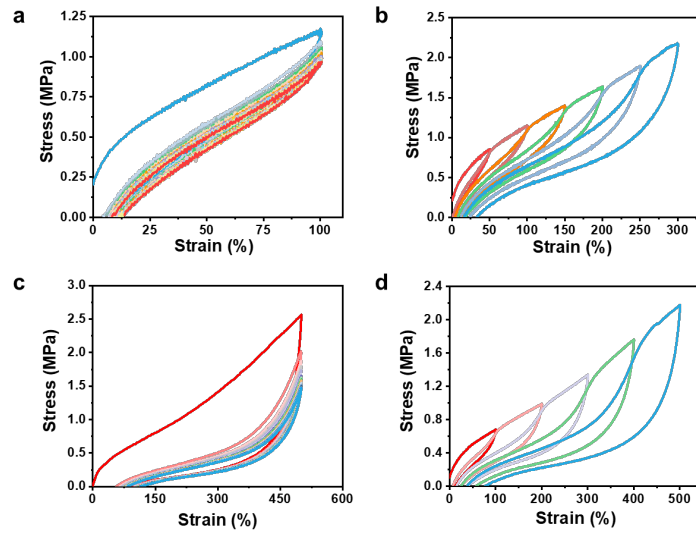
Supplementary Figure 17. Energy-dispersive X-ray spectroscopy (EDS) mapping of LMAS yarns after multiple stripping of pressure-sensitive adhesive tape.



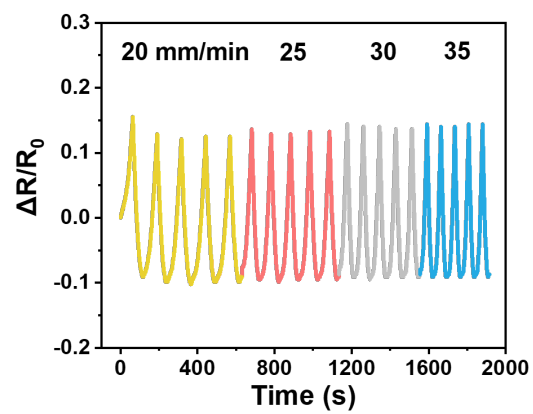
Supplementary Figure 18. SEM image of LMAS yarns at 350% of strain with high magnification.



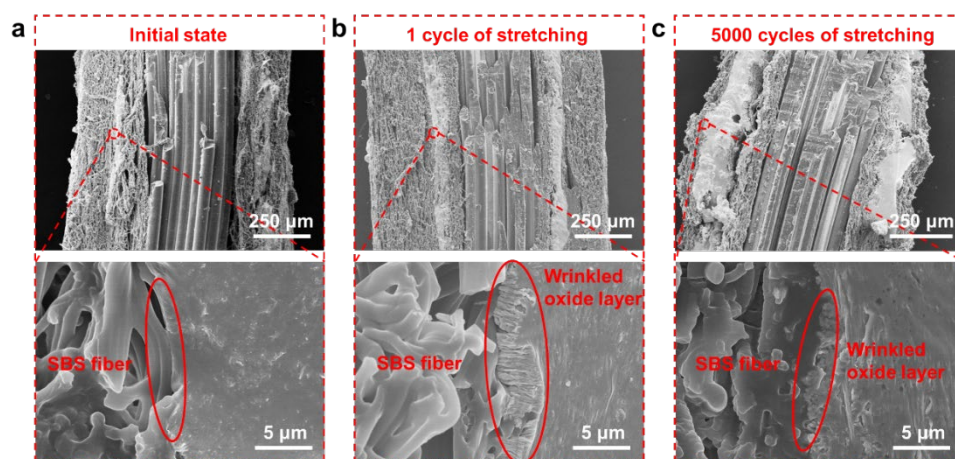
Supplementary Figure 19. Comparison of extension at break and Elastic modulus of SBS-PU yarns, Ag-SBS yarns, LM/Ag-SBS yarns and SLMAS yarns during stretching. The addition of solid or liquid fillers usually affects the mechanical properties of the material. First, the growth of Ag NPs as a rigid filler on the SBS-PU yarn decreases the elasticity, but the modulus of the yarn increases. In contrast, when the LM is absorbed into the yarn as a fluid, the modulus of the yarn decreases and the tensile properties increase slightly. Finally, the encapsulated layer of microfibers on the surface resulted in a slight reduction in the modulus of the SLMAS yarn.



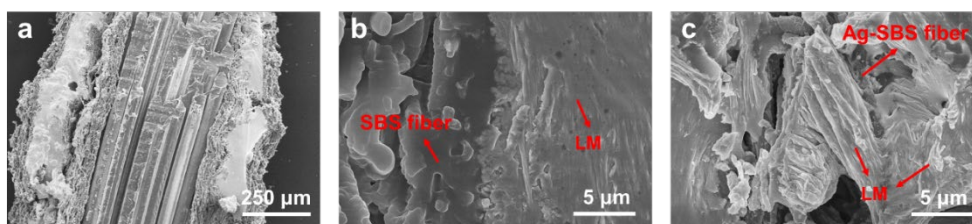
Supplementary Figure 20. **a** Cycling tensile curves of SLMAS yarns at 100% strain (20 cycles). **b** Cycling tensile curves of SLMAS yarns at different tensile strains (50%-300%). **c** Cycling tensile curves of SLMAS yarns at 500% strain (20 cycles). **d** Cycling tensile curves of SLMAS yarns at different tensile strains (100%-500%).



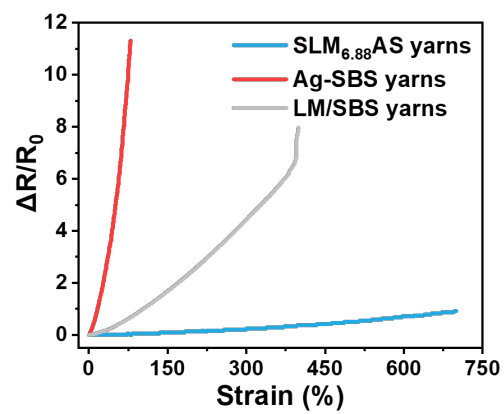
Supplementary Figure 21. Resistance changes of the SLMAS yarn at different strain rates (20-35 mm/min).



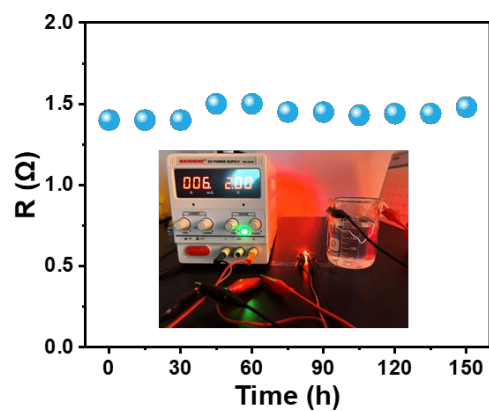
Supplementary Figure 22. **a** Longitudinal cross-section SEM image of SLMAS yarn in the initial state. **b** Longitudinal cross-section SEM image of SLMAS yarn after 1 stretching cycle (500% strain). **c** Longitudinal cross-section SEM image of SLMAS yarn after 5000 stretching cycles (500% strain).



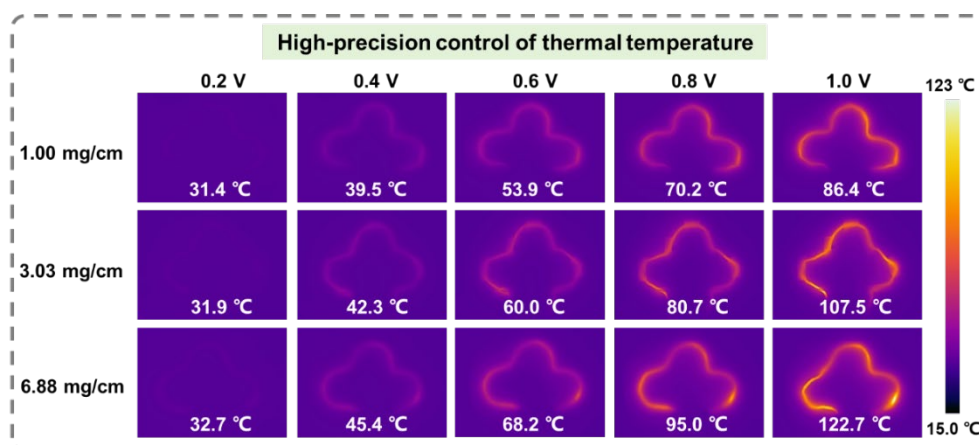
Supplementary Figure 23. a-c Longitudinal cross-section SEM image of SLMAS yarn after 5000 stretching cycles (500% strain) at different magnifications.



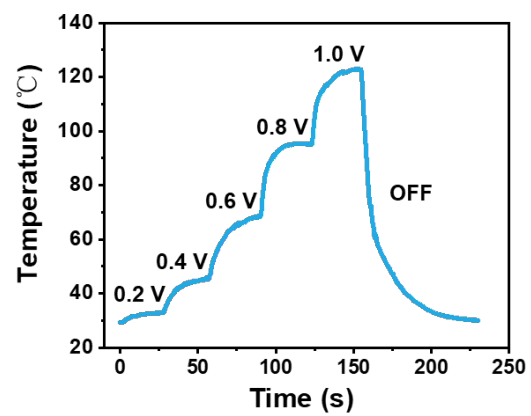
Supplementary Figure 24. Resistance changes of Ag-SBS yarns, LM/SBS yarns, and SLMAS yarns during stretching.



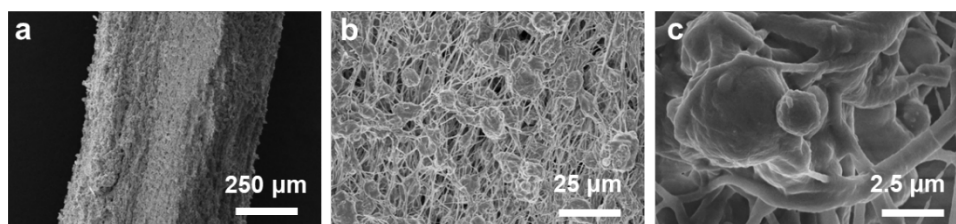
Supplementary Figure 25. Resistance changes of the SLMAS yarn under water. The inset is the image showing that the SLMAS yarns could long-term steadily light the LEDs under water.



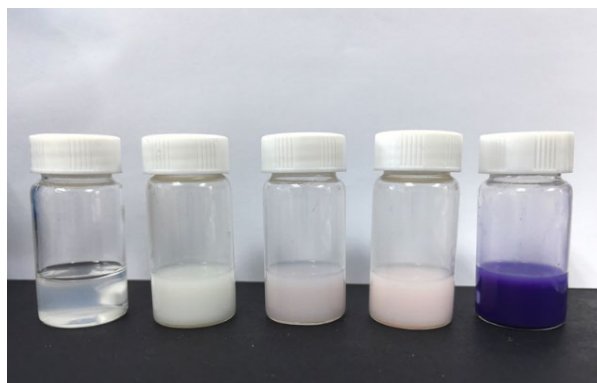
Supplementary Figure 26. IR images of SLMAS yarns with different LM loading at 0.2 V, 0.4 V, 0.6 V, 0.8 V, and 1.0 V (yarn length: 15 cm).



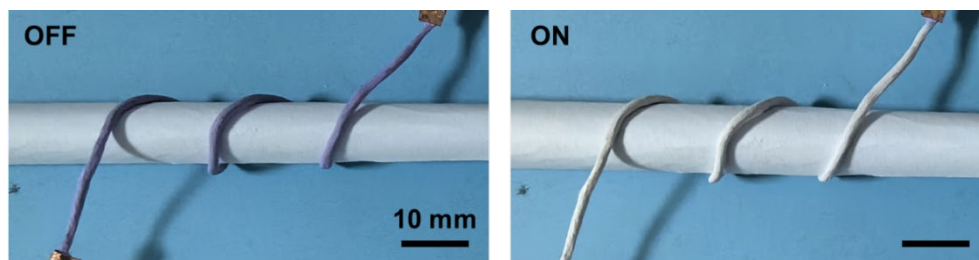
Supplementary Figure 27. Temperature change of a SLMAS yarn at 0.2 V, 0.4 V, 0.6 V, 0.8 V, and 1.0 V.



Supplementary Figure 28. a-c The SEM images of electro-thermochromic yarns at different magnifications.



Supplementary Figure 29. Optical picture of electrostatic spinning solution. From left to right, these are pure SBS solution, light green to deep green thermochromic solution, light purple to deep purple thermochromic solution, light pink to deep pink thermochromic solution, purple to white thermochromic solution.



Supplementary Figure 30. Optical images of electro-thermochromic yarns during winding by switching the voltage on and off.

References

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