Wearable Self-Powered Intelligent Textile with Optical-Electrical Dual-Mode Functionality for Pressure Distribution Detection and Remote Intelligent Control

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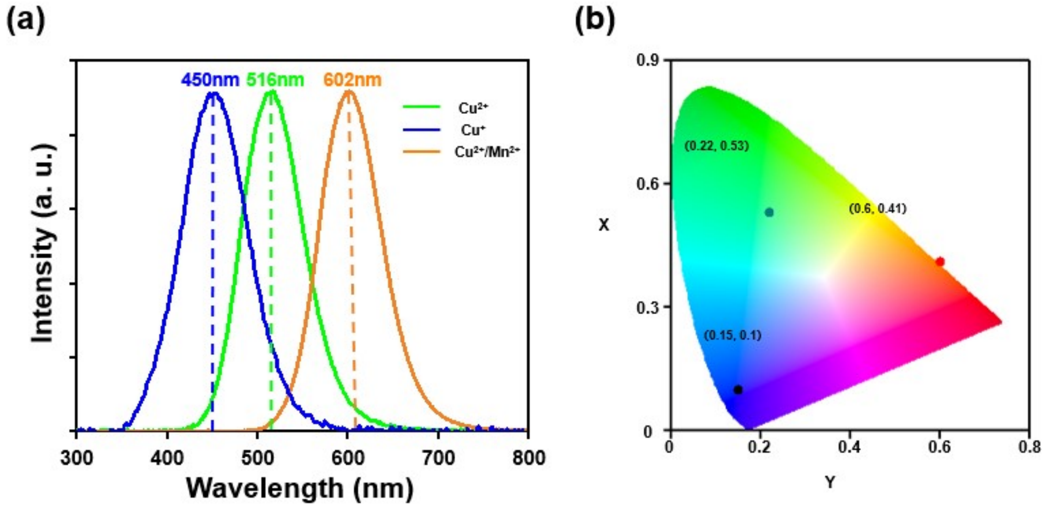

Fig. S1. (a) The photoluminescent spectra and (b) the CIE coordinates of WSIT with different phosphors (ZnS:Cu^{2+}, ZnS:Cu^{2+}/Mn^{2+}, and ZnS:Cu^{+} phosphors) of blue, green, and orange lights.

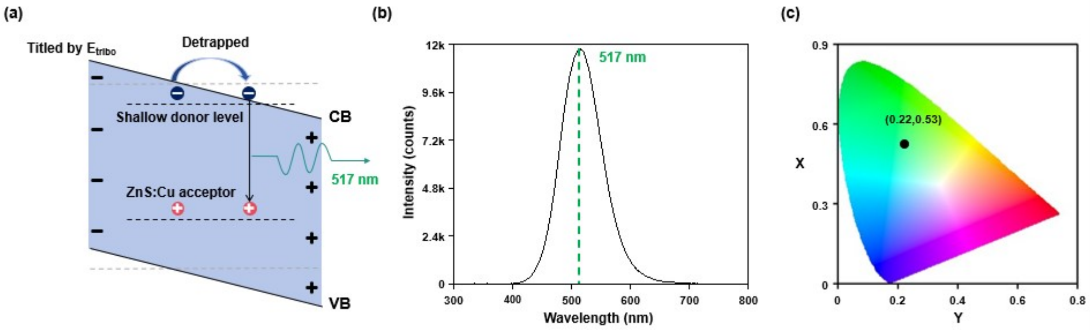

Fig. S2. (a) Band diagram indicating the TIEL mechanism of the ZnS:Cu. (b) A typical TIEL spectrum of the WSIT and (c) its corresponding CIE coordinates.

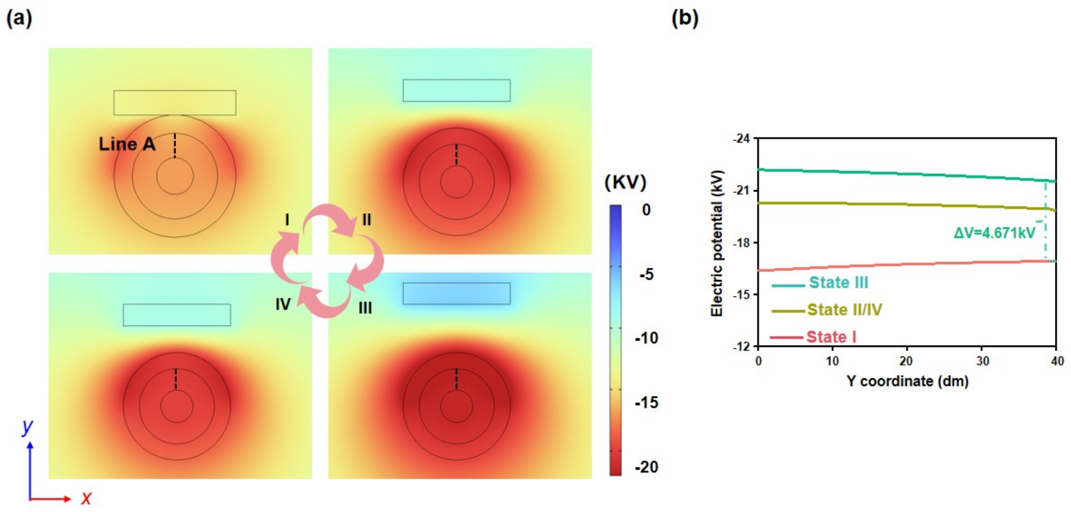

Fig. S3. (a) Numerical calculation of the electric potential distribution of ZnS:Cu phosphors in four states within a complete contact-separation working cycle through COMSOL software. (b) The corresponding electric potential variation along the black dashed line A in the four states in (a).

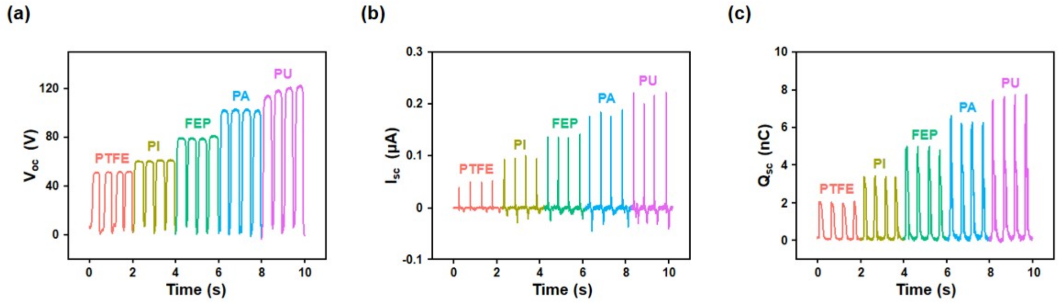

Fig. S4. Electrical output (a) V_{oc}, (b) I_{sc} and (c) Q_{sc} of WSIT as obtained when the five types of materials are taken as the contacting object. (Pressure:5 N, Frequency: 2 Hz)

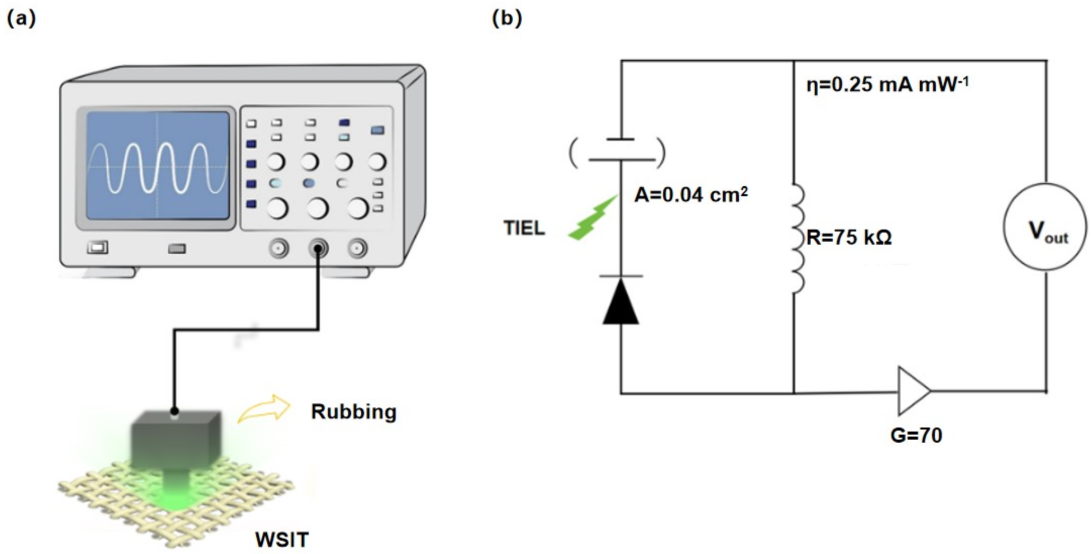

Fig. S5. (a) Schematic diagram of the test platform developed for the quantitative measurement of the optical power density of the WSIT. (b) Working mechanism of the TIEL optical power density detection performed by using a customized photodetector and the major parameters of the photodetector.

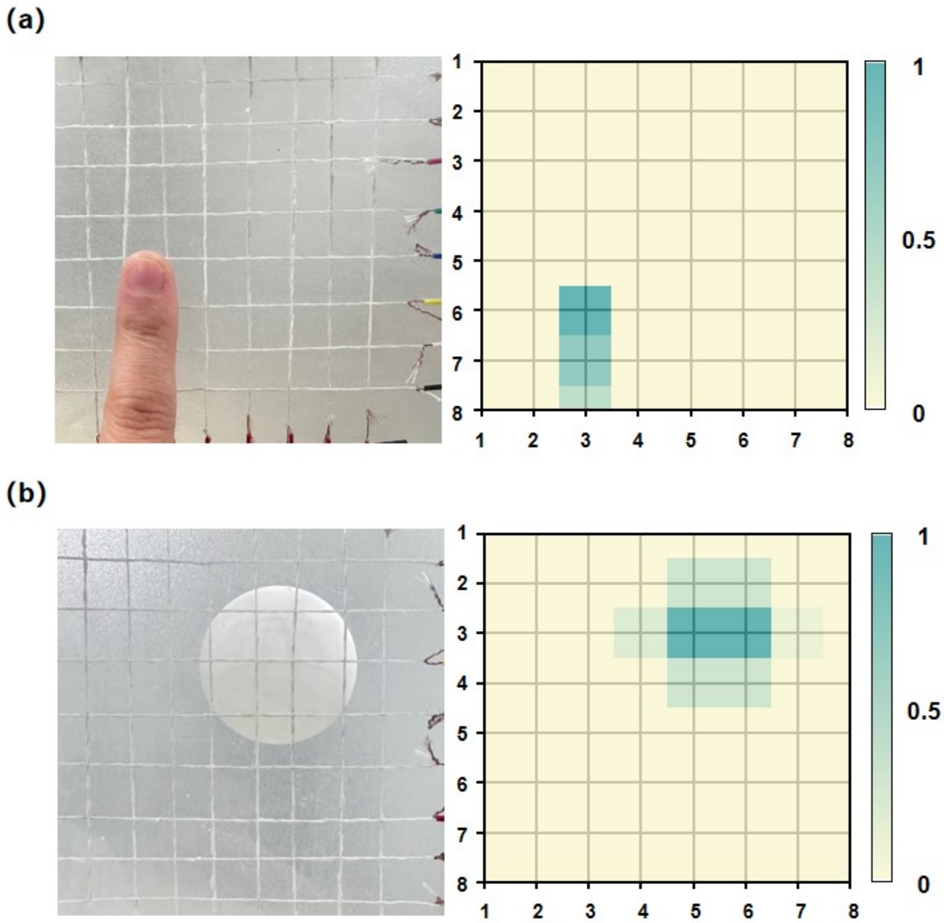

Fig. S6. (a) Photographs of the 8×8 pixels sensing fabric when a finger was pressed on the fabric and the corresponding 3D output signals. (b) Photographs of the 8×8 pixels sensing fabric when a table tennis ball was gently pressed on the fabric and the corresponding 3D output signals.

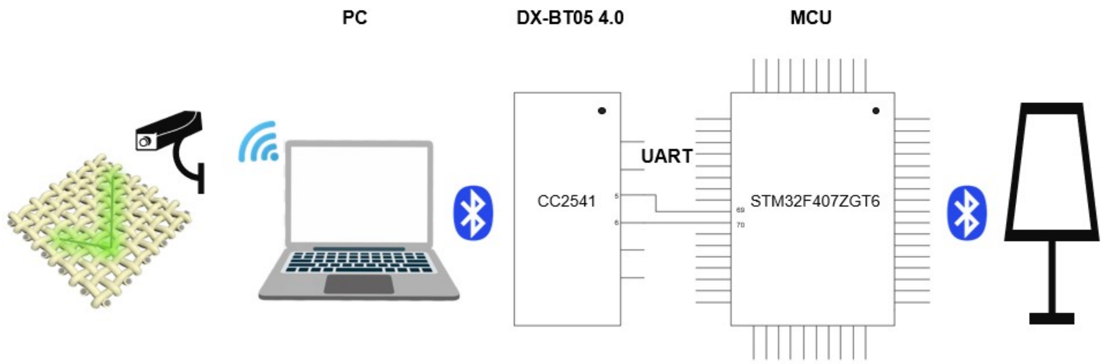

Fig. S7. The flow chart of the intelligent control system for a desk lamp through TIEL signals.

Table S1. A summary of ML/EL-based fabric sensors in terms of mechanism, trigger pressure/driving voltage, materials, brightness, electrical output, stability, washability, preparation method, and practical application.

Year /Ref.	Mechanism	Trigger pressure (MPa) /Driving voltage (V)	Materials (outside-to-inside)	Brightness	Electrical outputs	Stability	Washability	Preparation method	Application
2023[1]	ML	0.5 MPa	ZnS:Cu/PDMS@PU	None	None	5000 cycles	None	Dip-coating	Human motion monitoring
2020[3]	EL	35 V	ZnS:Cu@PDMS/Cu	None	None	1500 cycles	None	Dip-coating	Human motion monitoring
2021[9]	ML	None	ZnS:Cu@PDMS/Cu	None	6.5 V; 50 nA; 2.2 nC	None	Yes	Dip-coating	Human motion monitoring
2017[15]	EL	30 V; 2 kHz	Silicone@ZnS/Silicone @Ag Nws/PET	202 cd/m^2	None	500 cycles	Yes	Dip-coating	Colorful display
2021[16]	ML	1.5 MPa	SEBS@ZnS:Cu/P(VDF -TrFE)/Ni-Cu	None	9 V; 6.4 nC	100000 cycles	Yes	Fermat spinning; Melt-spinning	Underwater rescue; Human-machine interface
2021[30]	EL	7.5 V; 2 kHz	Silicone/ZnS@PU/ Nylone/Ag	115.1 cd/m^2	None	100 cycles	Yes	Dip-coating; Melt-spinning	Smart node; Communication platform
2023[32]	EL	100 V; 1 kHz	ZnS@PU/Nylone/Ag	149 cd/m^2	None	None	Yes	Coaxial wet-spinning	Rain-sensing; Liquid identification
2019[48]	TIEL	9.8 MPa	PTFE/ZnS:Cu@PDMS	None	None	None	None	Casting	Wearable display
2021[49]	EL	18 V	ZnS@Dragon skin/Liquid metal/Silicone/Spandex	488 cd/m^2	None	None	Yes	Dip-coating	Controllable pattern display
2018[50]	EL	100 V; 1.5 kHz	Hydrogel/ZnS:Cu@ Silicone	None	None	1000 cycles	None	Coaxial wet-spinning	Brain-interfaced communications
This work	TIEL	1 N; 0.002 MPa	Skin/PTFE/ZnS:Cu@P MMA/Nlyon/Ag	5.17 μW/cm^2	120V; 0.25 μA; 8nC	2000 cycles	Yes	Electrospinning; Dip-coating	Pressure detection; Intelligent control; Smart home

"None" means not mentioned; SEBS: Poly(styrene-b-(ethylene-co-butylene)-b-styrene; P(VDF-TrFE): Poly(vinylidene fluoride-trifluoroethylamine); PDMS: Polydimethylsiloxane; PTFE: Poly tetrafluoroethylene; PU: Polyurethane; PMMA: Polymethyl methacrylate; PET: Polyethylene glycol terephthalate

Note S1. COMSOL model setting

In the process of simulation, the radius of conductive yarn is set to 0.3 mm, the thickness of ZnS:Cu@PMMA coating is set to 0.4 mm, and the thickness of PTFE coating is set to 0.3 mm. The distance from state II and state IV from skin to WSIT is fixed at 0.5 mm. In State III, the distance between the skin and WSIT is set to 0.9 mm. The surface charge density of the skin and PTFE is set to 2×10^{4} C/m^2 and 2×10^{-4} C/m^2, respectively. The unit as a whole is surrounded by a ground air block with a side length of 100 mm. The dielectric constants set for the simulation are as follows: $\varepsilon = 1.0$ (air), $\varepsilon = 1$ (skin), $\varepsilon = 2.2$ (PTFE), $\varepsilon = 3.5$ (PMMA), and $\varepsilon = 1$ (silver wire).

Note S2. Estimated optical power density (P) of TIEL

An oscilloscope and a light detector are used to measure the optical voltage V. The optical power density (P) is calculated through the following equation.

$$P = \frac{V}{\eta G R S}$$

where V represents the measured photovoltage; η denotes the optical conversion efficiency, which is 0.25 mA mW^{-1}; G refers to the gain, which is 70; R indicates the resistance, which is 75 kΩ; S represents the effective sensitive area of the light detector, which is 4 mm^2.

Note S3. Illustration of the self-developed software for remote intelligent control of an entertainment game

The optical flow tracking algorithm starts by extracting the representative feature points from the image. Then, it matches the feature points between adjacent frames, so as to find the corresponding pair of feature points. Given the matched pair of feature points, the motion vector of each feature point is calculated by comparing the difference in brightness of these pixel points. The calculated motion vector is used to estimate the overall motion of the external object for further control the motion of the figure in the game.

Note S4. Illustration of the intelligent control system for a desk lamp

The schematic diagram of the flow chart of the system is shown in Fig. S7. Firstly, the camera is used to transmit the image to the computer. Then, the computer is used to process the input image, judge it through deep learning, and transmit the result to DX-BT05 MCU through Bluetooth. Finally, the MCU is used to figure out the instructions, determining and shifting the state of the desk lamp logically.