

Supporting Information *for*

Optical fiber sensor based on upconversion nanoparticles for internal temperature monitoring of Li-ion battery

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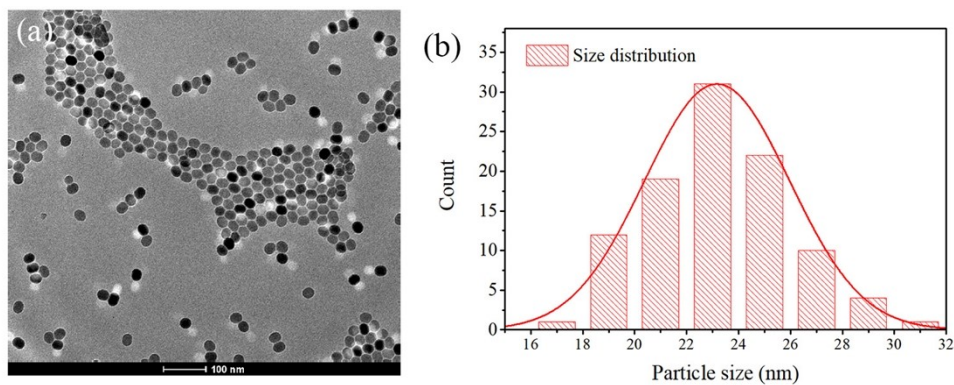


Figure S1 (a) TEM image of NaYF₄:Yb/Er, (b) size distribution chart of NaYF₄:Yb/Er.

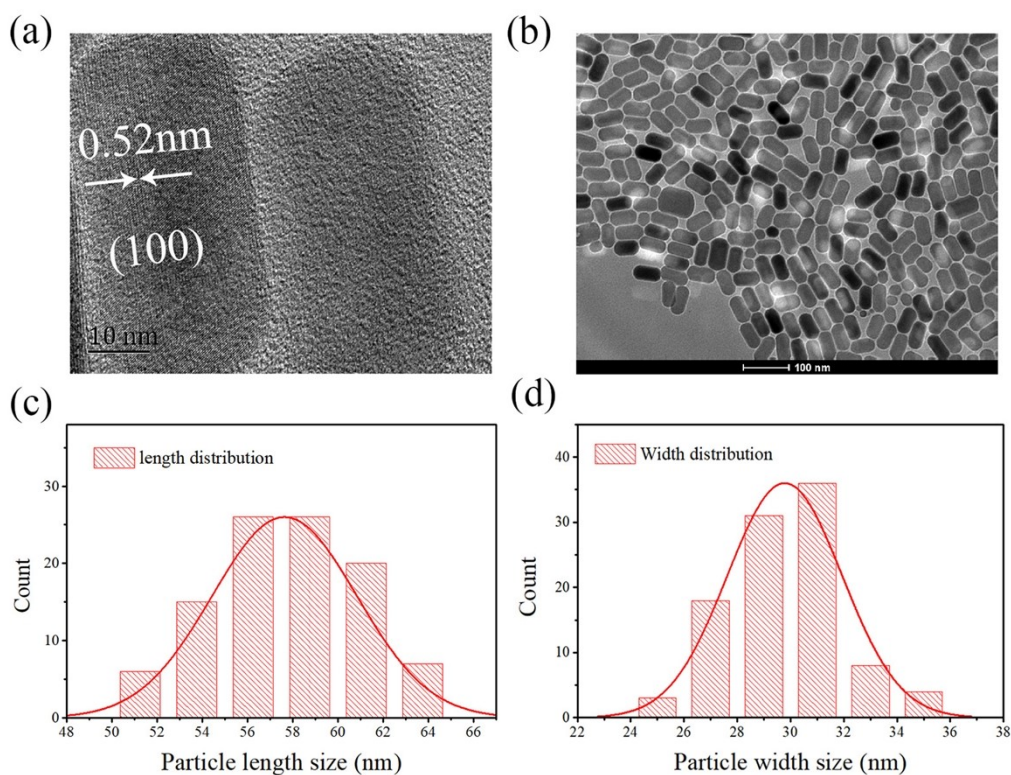


Figure S2 (a) HRTEM image and (b) TEM image of NaYF₄:Yb/Er@NaYF₄. (c and d) The size distribution charts of NaYF₄:Yb/Er@NaYF₄.

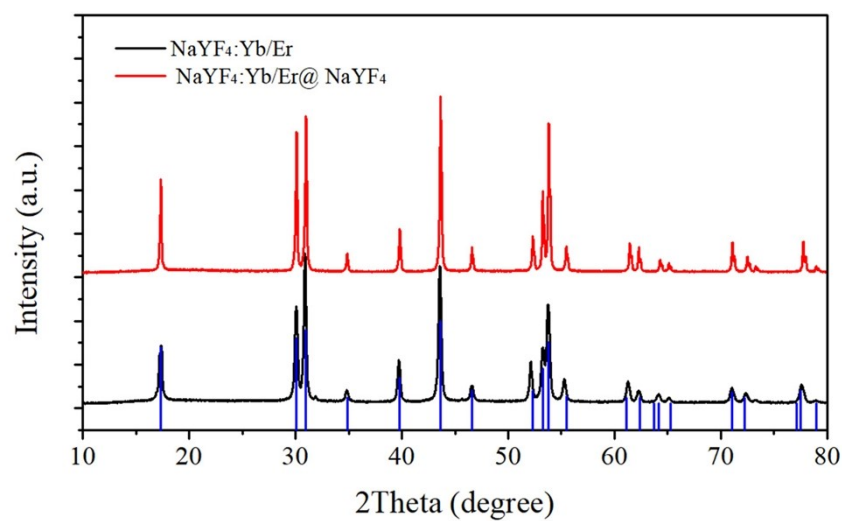


Figure S3 XRD patterns of $\text{NaYF}_4:18\%\text{Yb}/2\%\text{Er}$ and $\text{NaYF}_4:18\%\text{Yb}/2\%\text{Er}@ \text{NaYF}_4$; the blue vertical lines are the standard PDF card of JCPDS No. 16-0334.

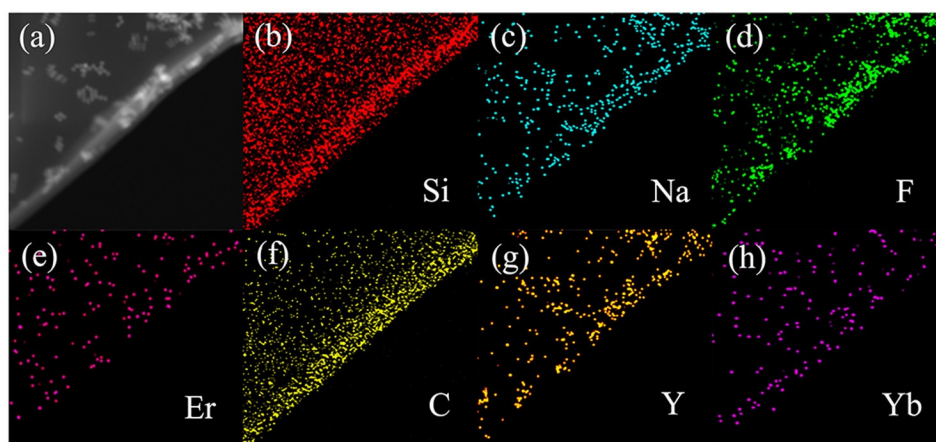
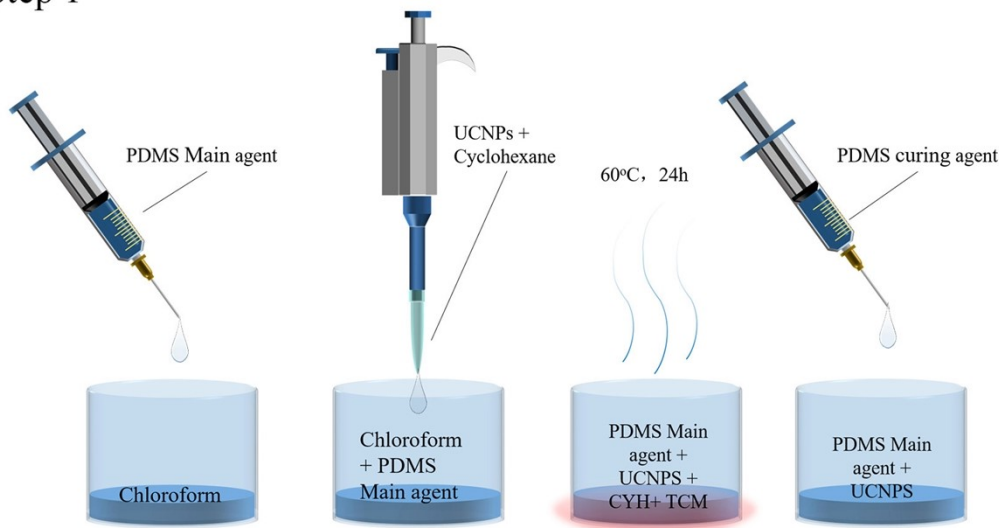


Figure S4 The element maps for Si, Na, F, Er, C, Y and Yb of UCNPs/PDMS.

Step 1



Step 2

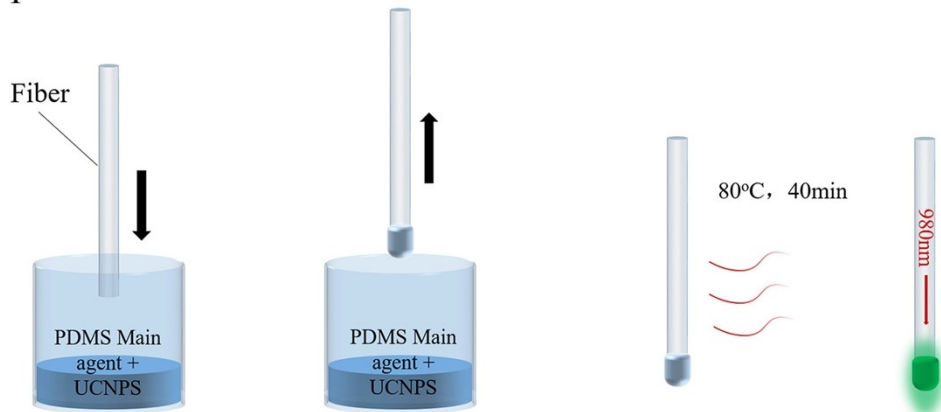


Figure S5 Step 1: Preparation of the UCNPs/PDMS. Step 2: Fabrication of the fiber probe.

Step 1 Preparation of the UCNPs/PDMS.

The composite was obtained by mixing the cyclohexane solution of UCNPs with polydimethylsiloxane (PDMS) diluted in chloroform. The specific steps as follow: the 0.005g of UCNPs was dispersed in 5ml cyclohexane solution by ultrasonic vibration. 0.5g of PDMS main agent is dissolved in 5ml of chloroform solution. The UCNPs colloidal solution and PDMS-chloroform were mixed and ultrasonicated for 1h. Mixed solution was placed in an atmosphere of 60 °C for 24h in order to volatilize chloroform and cyclohexane completely. The 0.05g of curing agent was added into the composite.

Step 2 Fiber probe preparation

Before the composite has solidified, a multi-mode fiber was dipped into the composite. Due to the adsorption force and gravity, the fiber end surface adsorbs a certain composite. Then, the optical fiber with UCNPs-PDMS composite was placed into an atmosphere of 80 °C for 40min to cure the composite.

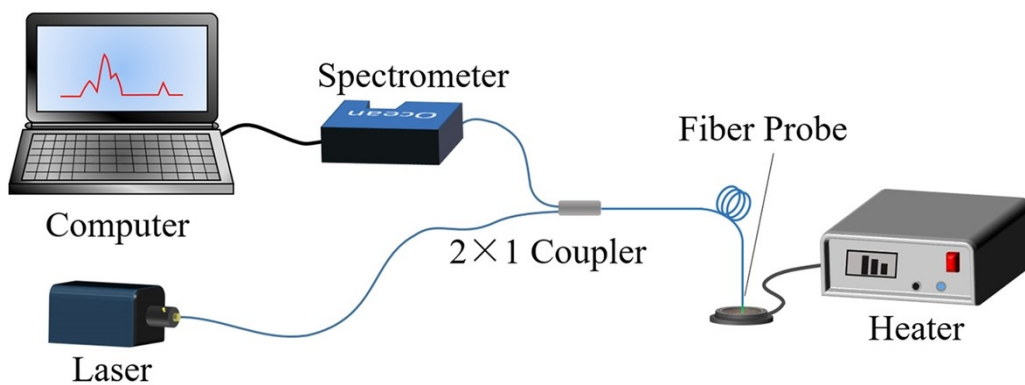


Figure S6 Schematic diagram of optical fiber temperature sensing device based on UCNPs/PDMS composite.

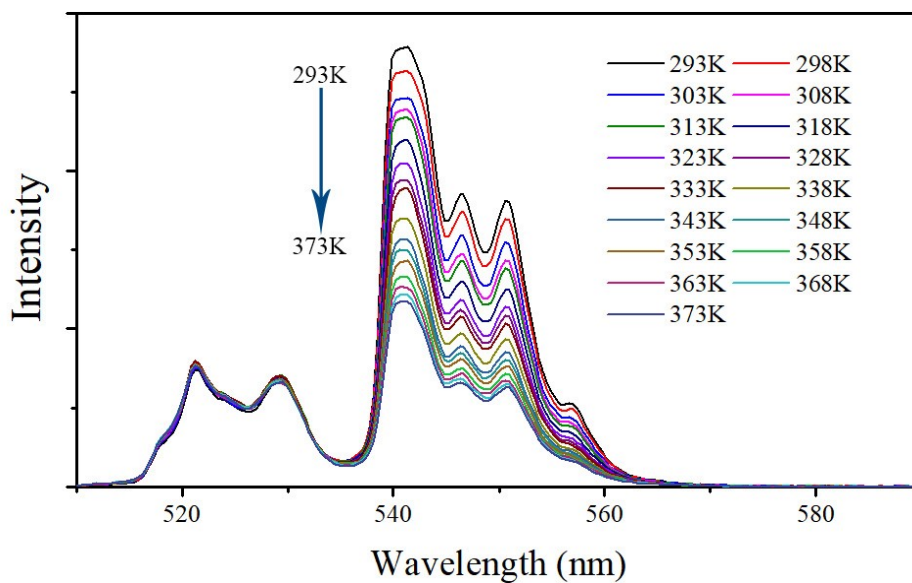


Figure S7 Temperature-dependent upconversion emission spectra in the range of 293-373 K. the emission spectra was recorded every 5 K.

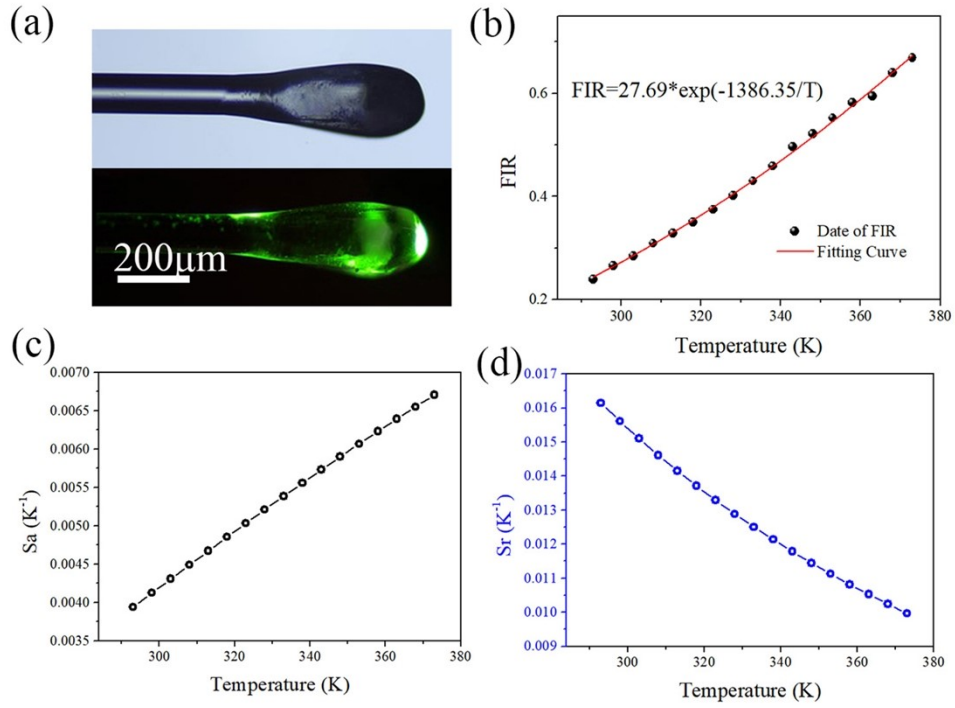


Figure S8 (a) The microscope image of fiber prober with size of $\approx 200\mu\text{m}$. (b) The FIR sensing of fiber prober. (c and d) The temperature sensitivity versus temperature.

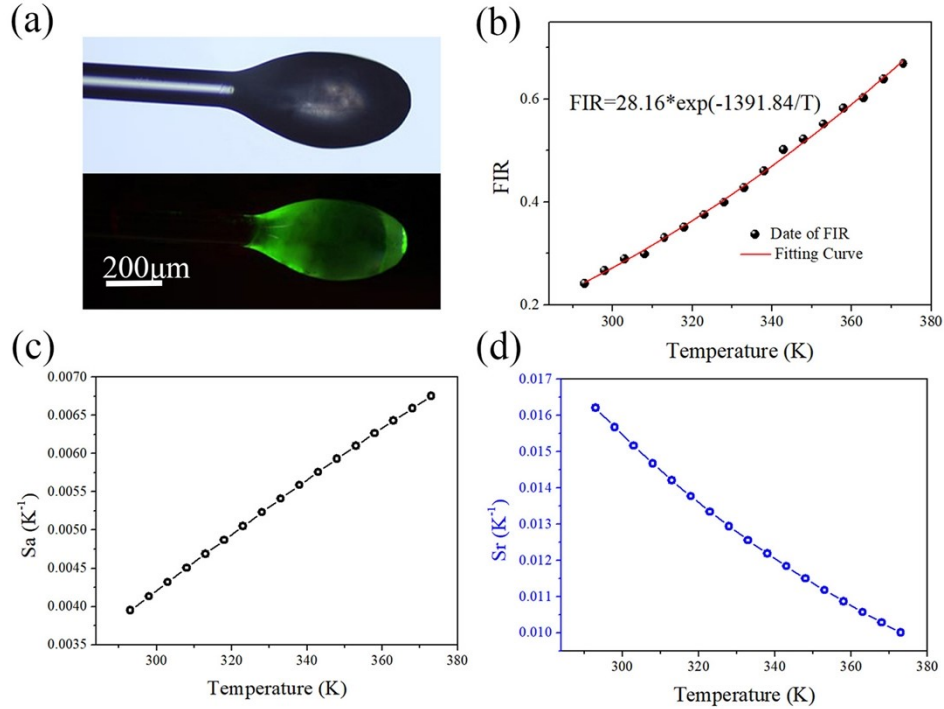


Figure S9 (a) The microscope image of fiber prober with size of $\approx 370\mu\text{m}$. (b) The FIR sensing of fiber prober. (c and d) The temperature sensitivity versus temperature.

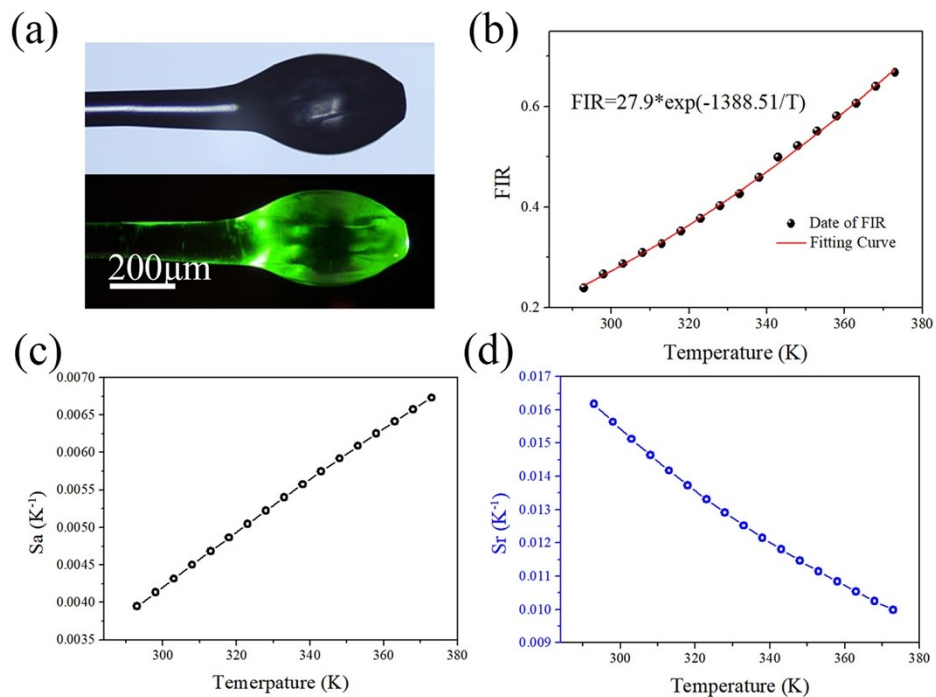


Figure S10 (a) The microscope image of fiber prober with size of $\approx 400\mu\text{m}$. (b) The FIR sensing of fiber prober. (c and d) The temperature sensitivity versus temperature.

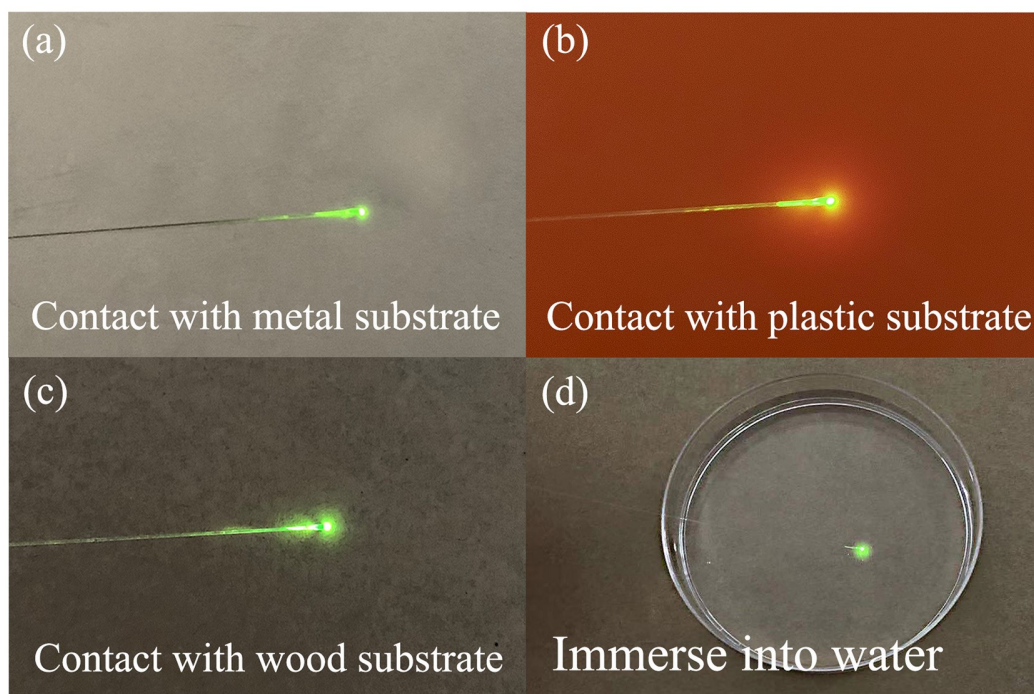


Figure S11 (a) The photograph of fiber probe contacted with different substrate: (a) metal substrate, (b) plastic substrate, (c) wood substrate and (d) water.

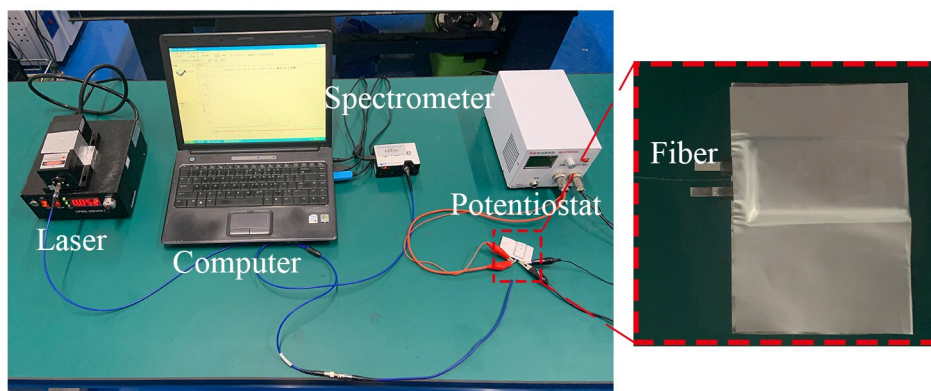


Figure S12 Battery temperature monitoring set up diagram.

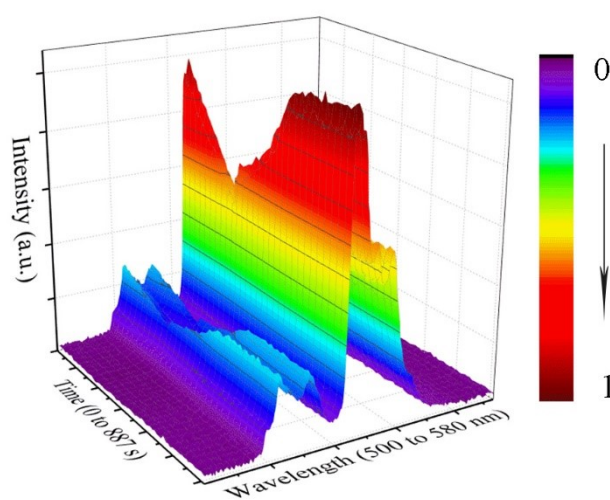


Figure S13 The real-time emission spectra of the optical sensor in a charging-discharging circle. The range of wavelength is 500 nm to 580 nm, the duration of a charging-discharging circle is approximately 887 s.