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National Cheng Kung University

PEDOT:PSS/CNT Thermoelectric Films for Wireless Fire-Risk Monitoring

Thermal Transport Tuning and Wireless Alert Prototype

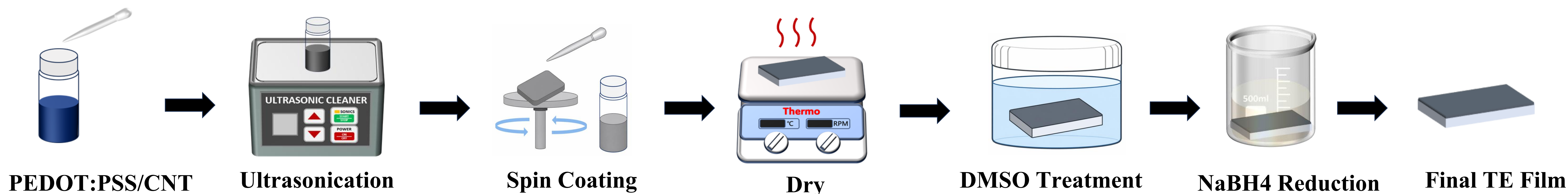
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1. ABSTRACT

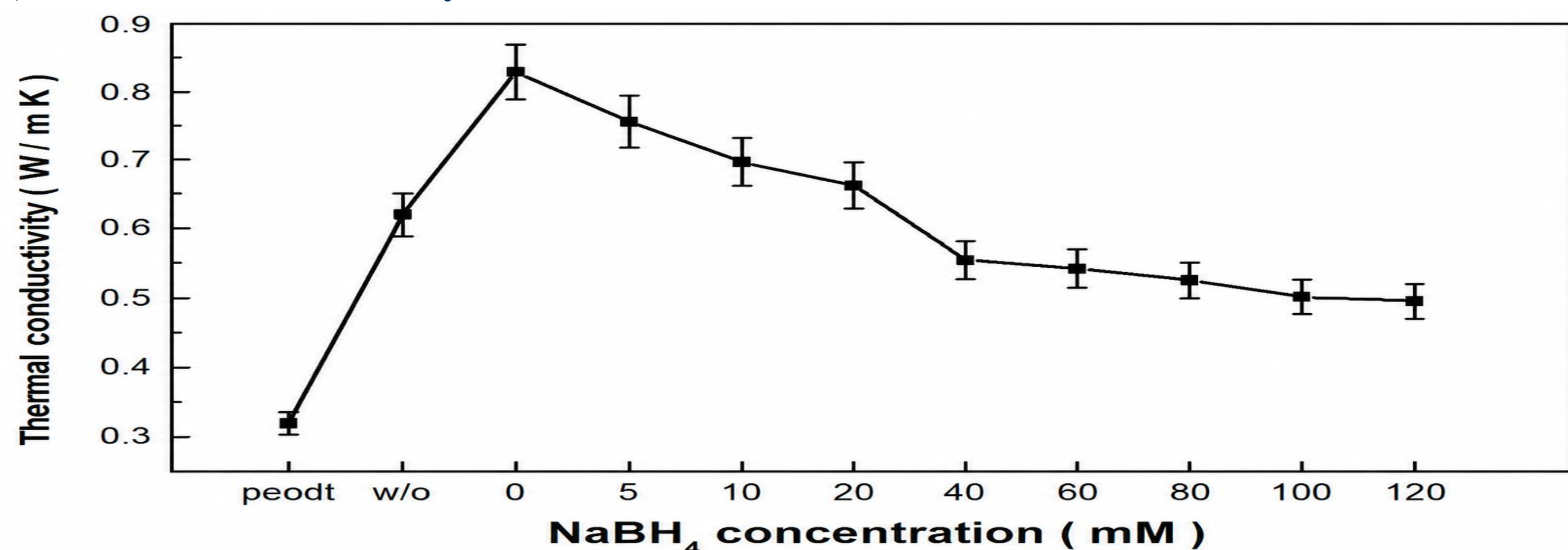
PEDOT:PSS/CNT composite films were fabricated as flexible thermoelectric sensing materials for early fire-risk monitoring. CNT incorporation and DMSO treatment increased the thermal conductivity from 0.32 to $0.83 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$, while NaBH_4 treatment reduced it to approximately $0.50 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$ through dedoping and defect-induced phonon scattering. A prototype sensor integrating AD620 signal amplification and ESP32 wireless communication was developed to demonstrate the conversion of weak thermoelectric signals into practical warning outputs.

2. FABRICATION PROCESS

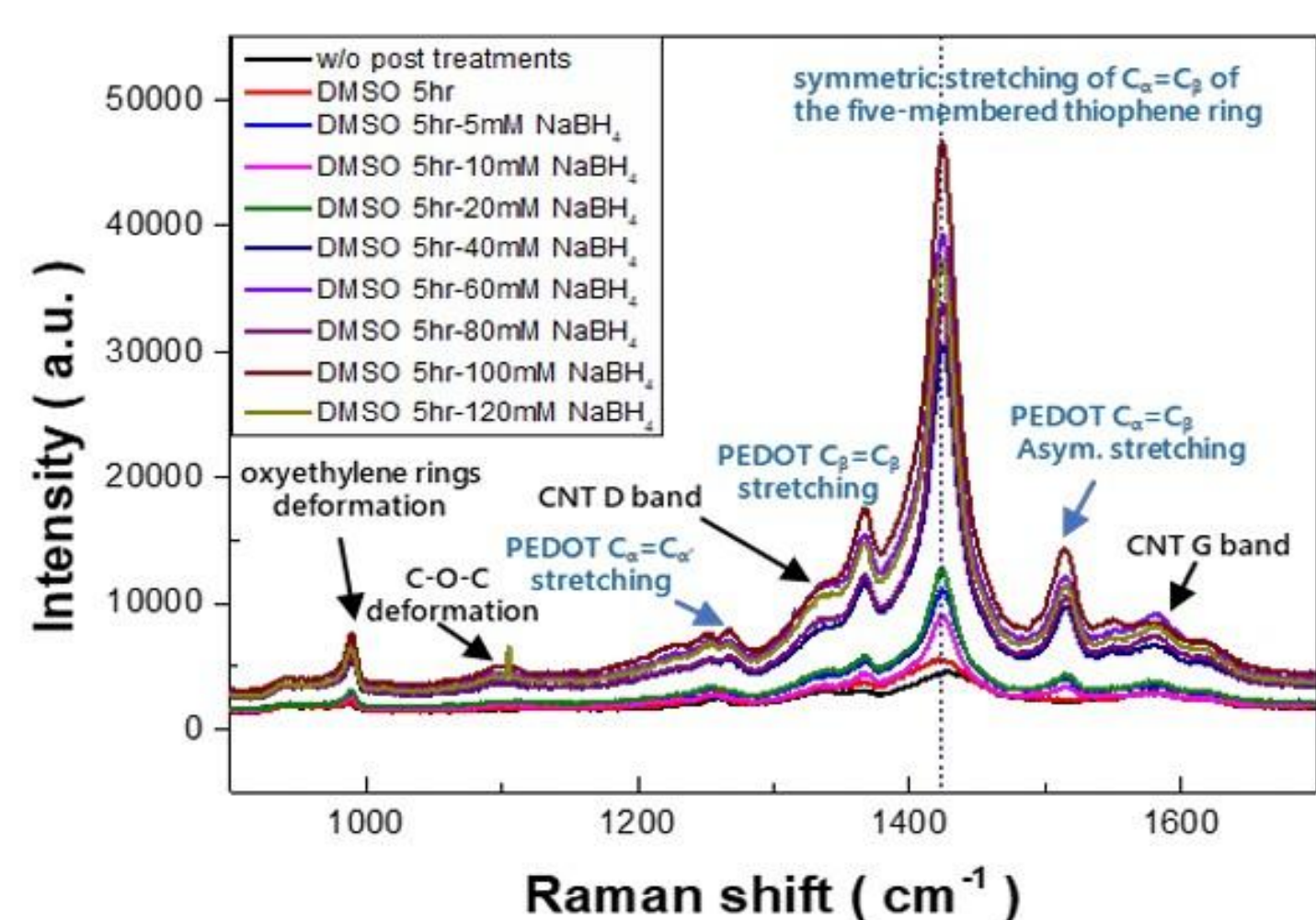


3. MATERIAL ANALYSIS & MECHANISM

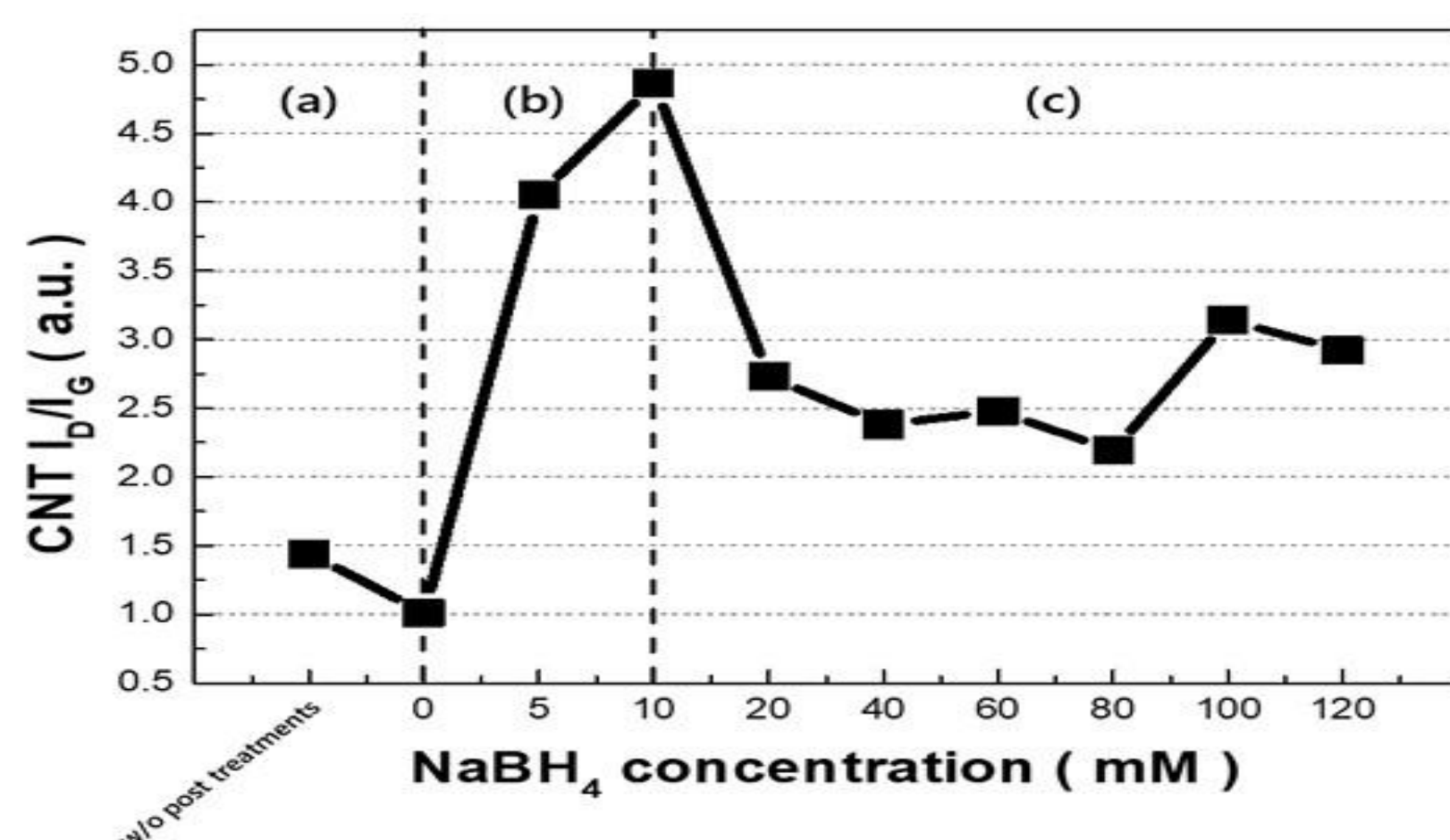
(a) Thermal Conductivity vs. NaBH_4 Concentration



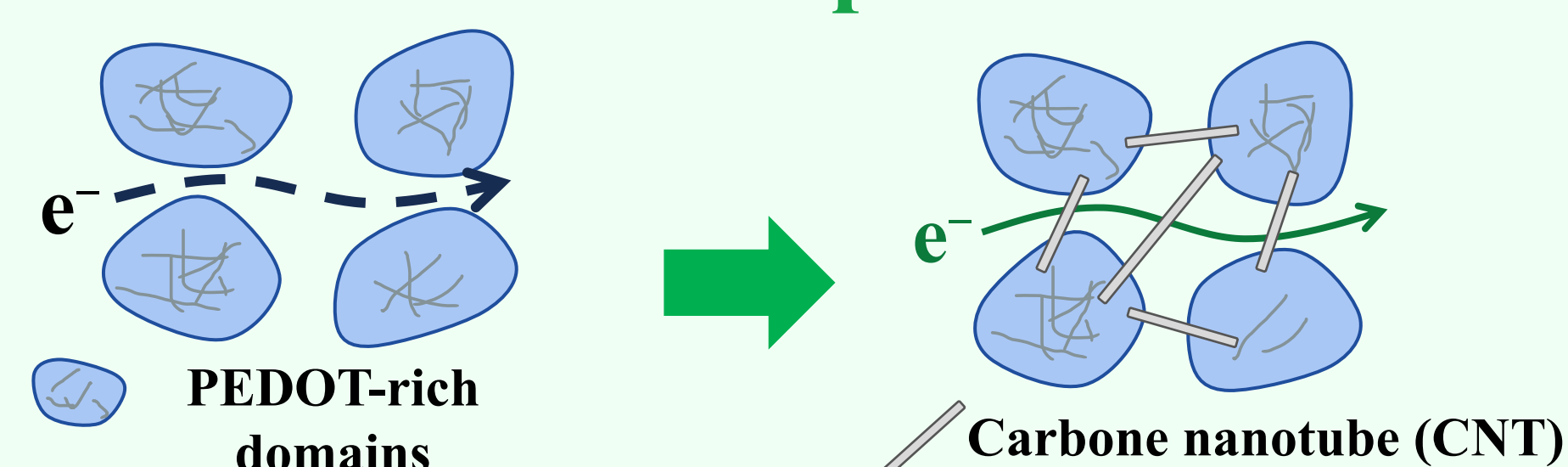
(b) Raman Spectra



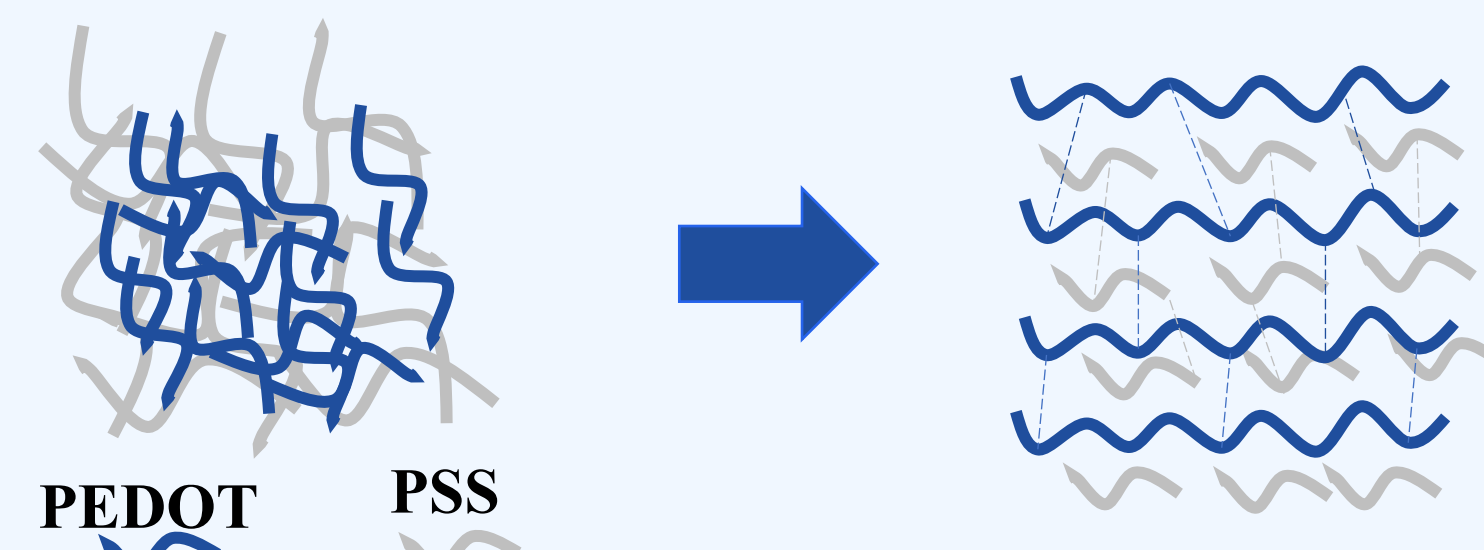
(c) CNT Dispersion Intensity



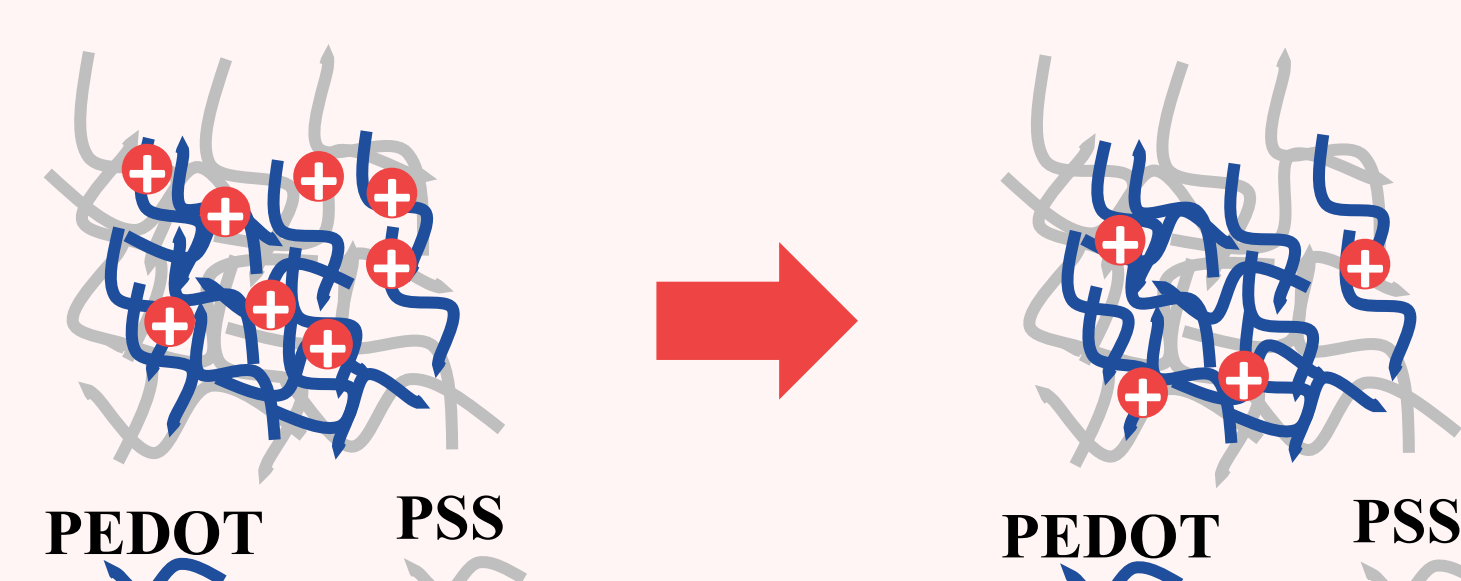
1. CNT Incorporation



2. DMSO Treatment



3. NaBH_4 Reduction



Core Result

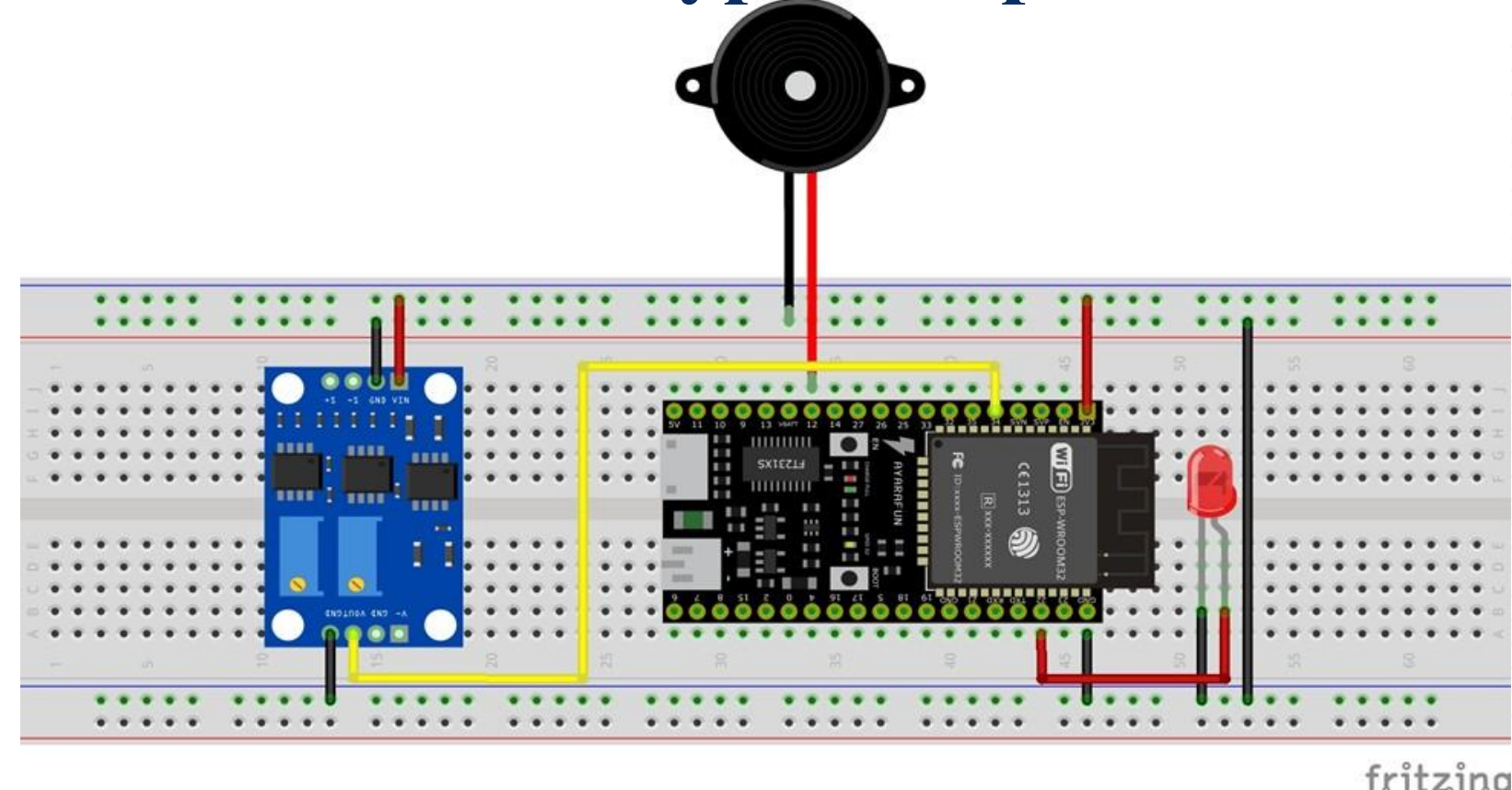
- Moderate NaBH_4 treatment improves CNT dispersion and thermal transport, while excessive reduction decreases κ due to dedoping and defect-induced phonon scattering.

Key Findings

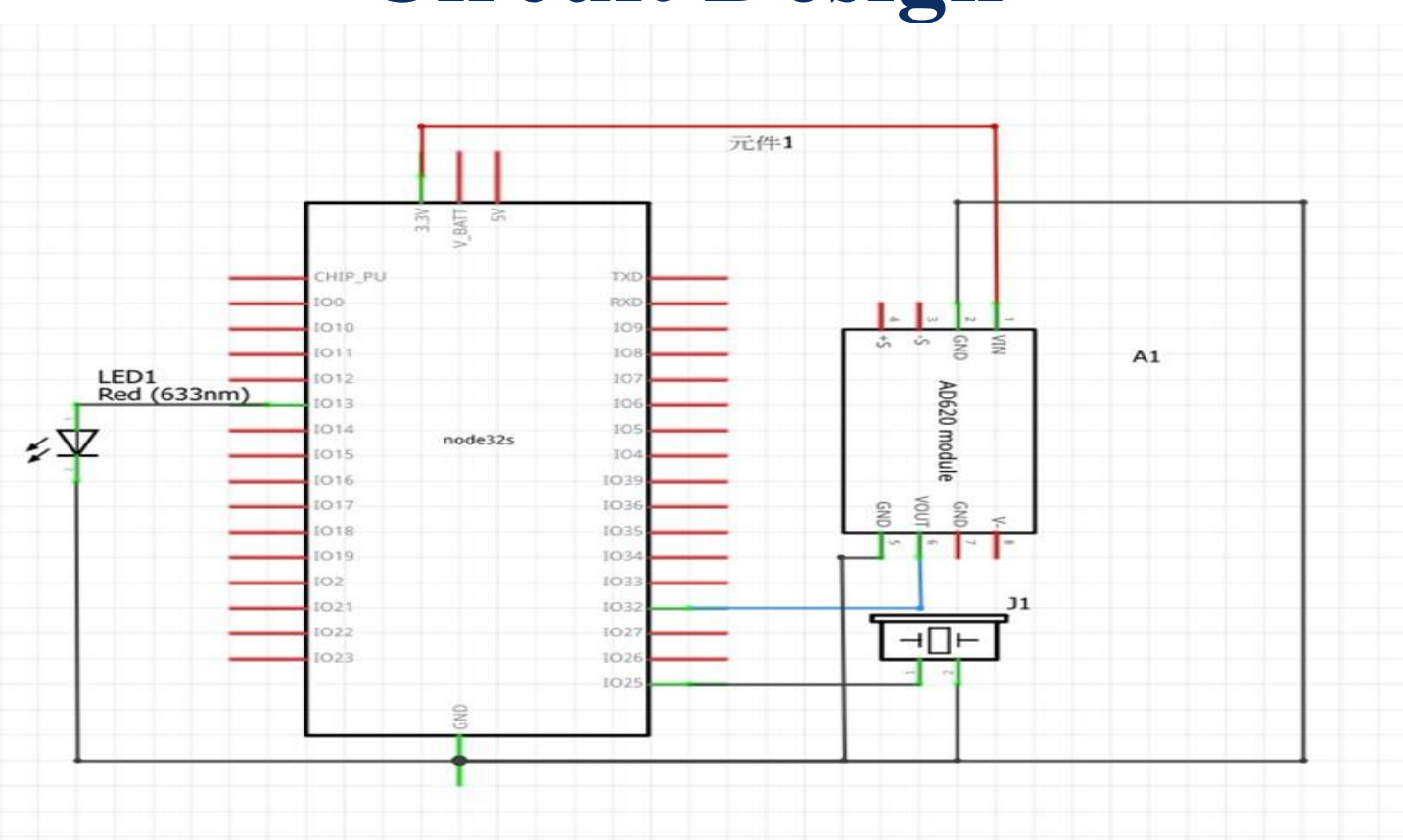
- CNT incorporation increased κ from 0.32 to $0.62 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$.
- DMSO treatment further enhanced κ to $0.83 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$.
- Excessive NaBH_4 reduced κ to $\sim 0.50 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$.

4. DEVICE INTEGRATION

Prototype Setup



Circuit Design



Temperature gradient $\rightarrow$ TE voltage $\rightarrow$ AD620 amplification $\rightarrow$ ESP32 acquisition $\rightarrow$ Wireless alert

- AD620 was used to **amplify** the weak thermoelectric voltage signal.
- ESP32 was used for **signal acquisition** and **wireless communication**.

5. CONCLUSION & FUTURE WORK

Material Platform

PEDOT:PSS/CNT films were demonstrated as flexible thermoelectric sensing materials for early fire-risk monitoring.

Transport Tuning

CNT, DMSO, and NaBH_4 treatments tuned κ from 0.32 to $0.83 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$, revealing the role of CNT dispersion and reduction-induced defects.

Future Work

Future work will focus on ΔT -voltage calibration, response time, and long-term stability.