Optimizing LDH and PVDF-TrFE Composite Layers for High-Performance Flexible Triboelectric Nanogenerators

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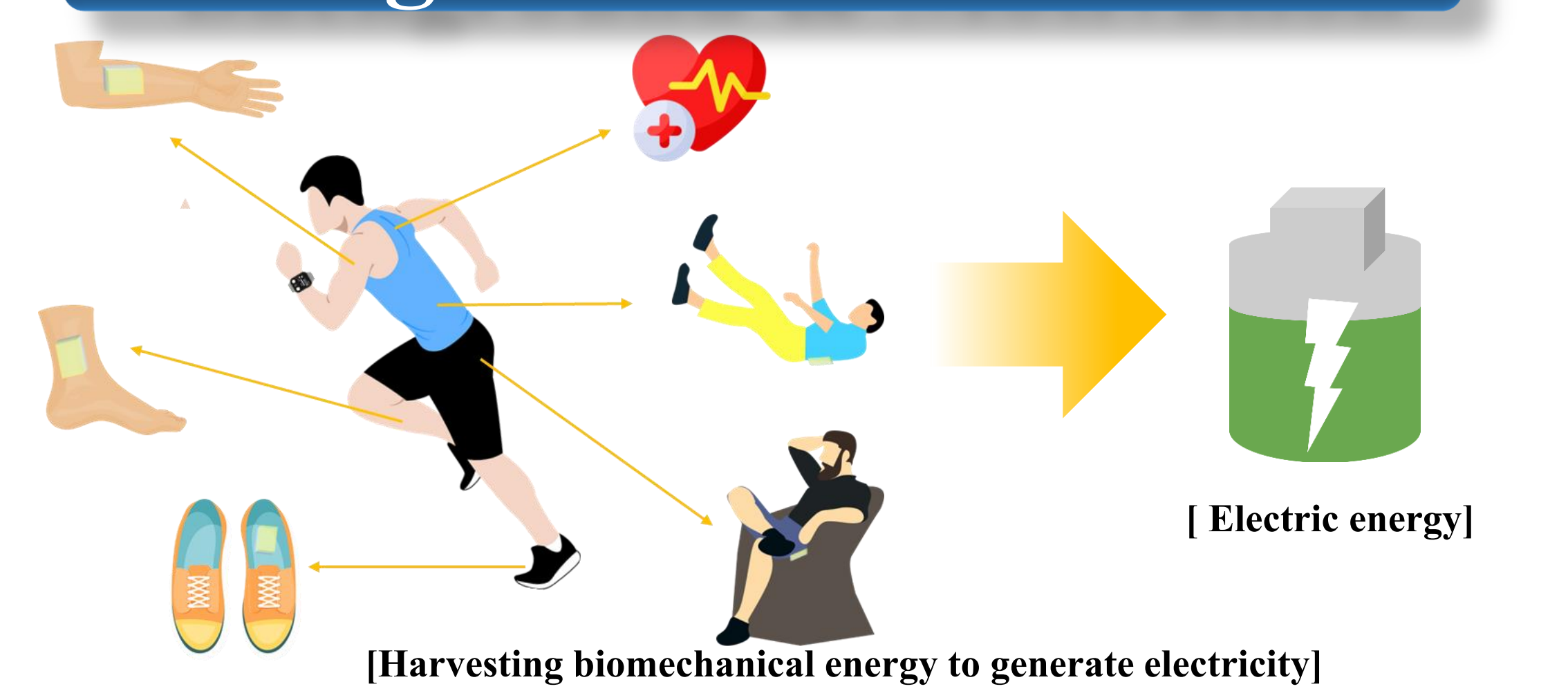
Background & Motivation

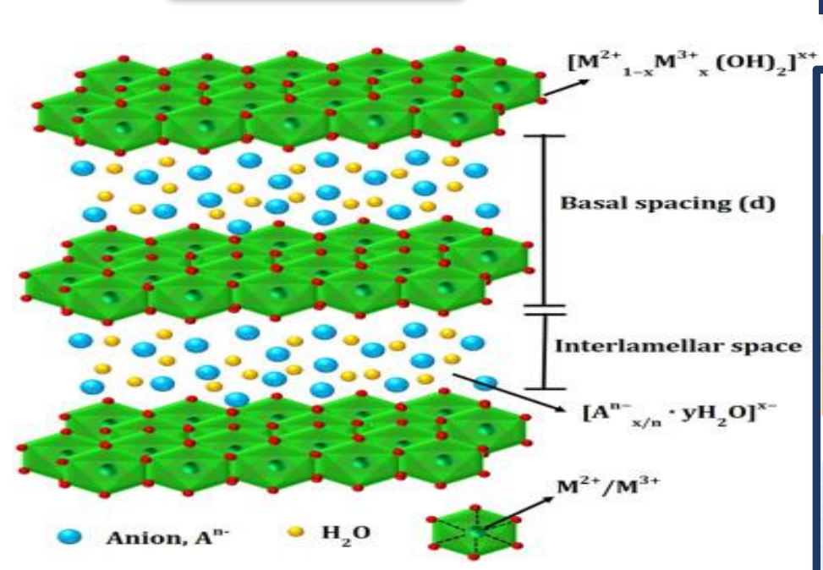

[Electric energy]

[Harvesting biomechanical energy to generate electricity]

Introduction

- As wearable and portable electronics continue to advance, the demand for sustainable energy harvesters has become crucial.
- Triboelectric nanogenerators (TENGs) offer a promising route, yet their performance strongly depends on surface and dielectric properties.
- In this work, high-performance TENGs were developed by combining optimized LDH surface modification and controlled PVDF-TrFE concentration on RF-sputtered AZO films to enhance triboelectric output efficiency.

LDH



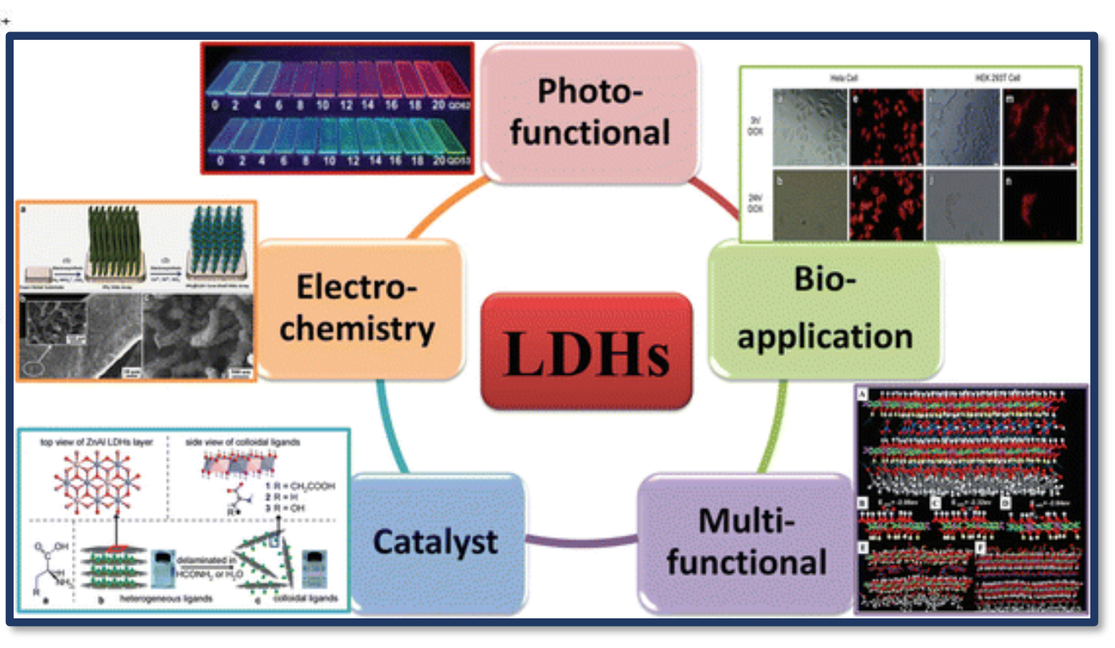
- General formula:

$M^{2+}_{1-x}M^{3+}_{x}(OH)_2]^{+}[A^{n-}]_{x/n}\cdot yH_2O$

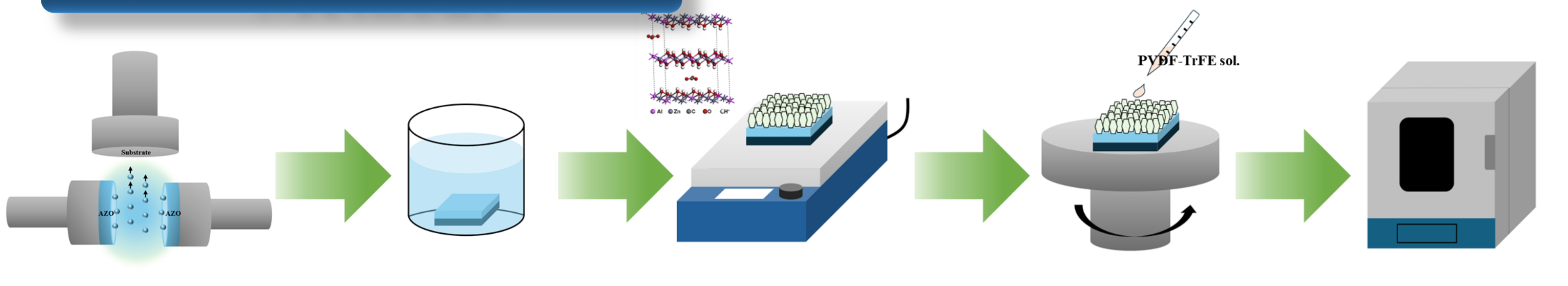
Where $M^{2+} = Mg^{2+}, Zn^{2+}$, etc; $M^{3+} = Al^{3+}, Fe^{3+}$, etc;

And $A^{n-} = CO_3^{2-}, OH^-, Cl^-$, etc

Applications of LDH materials

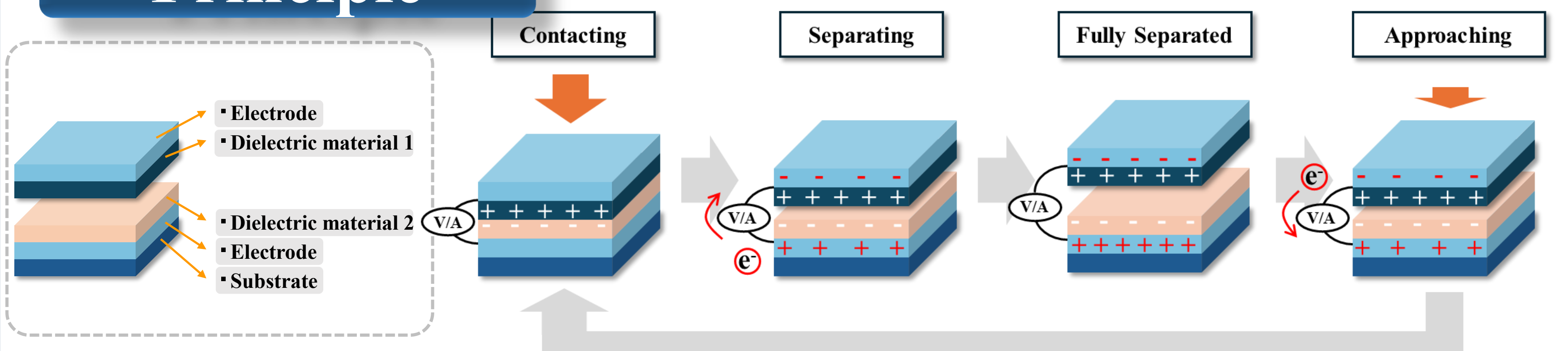


Methods



[Sputtering] [Dipping In DI water] [Hot plate] [Spin coating] [Oven]

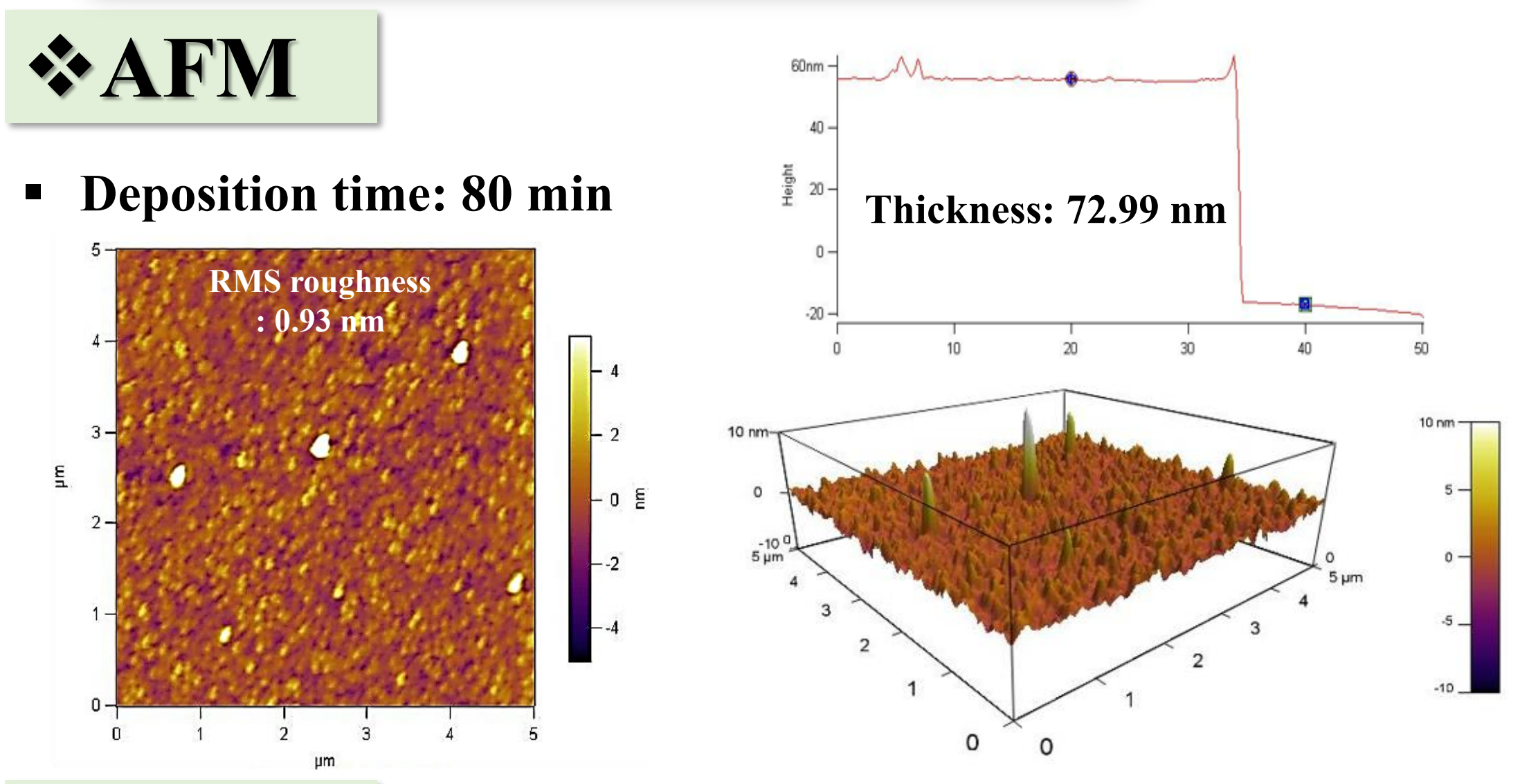
Principle



Results

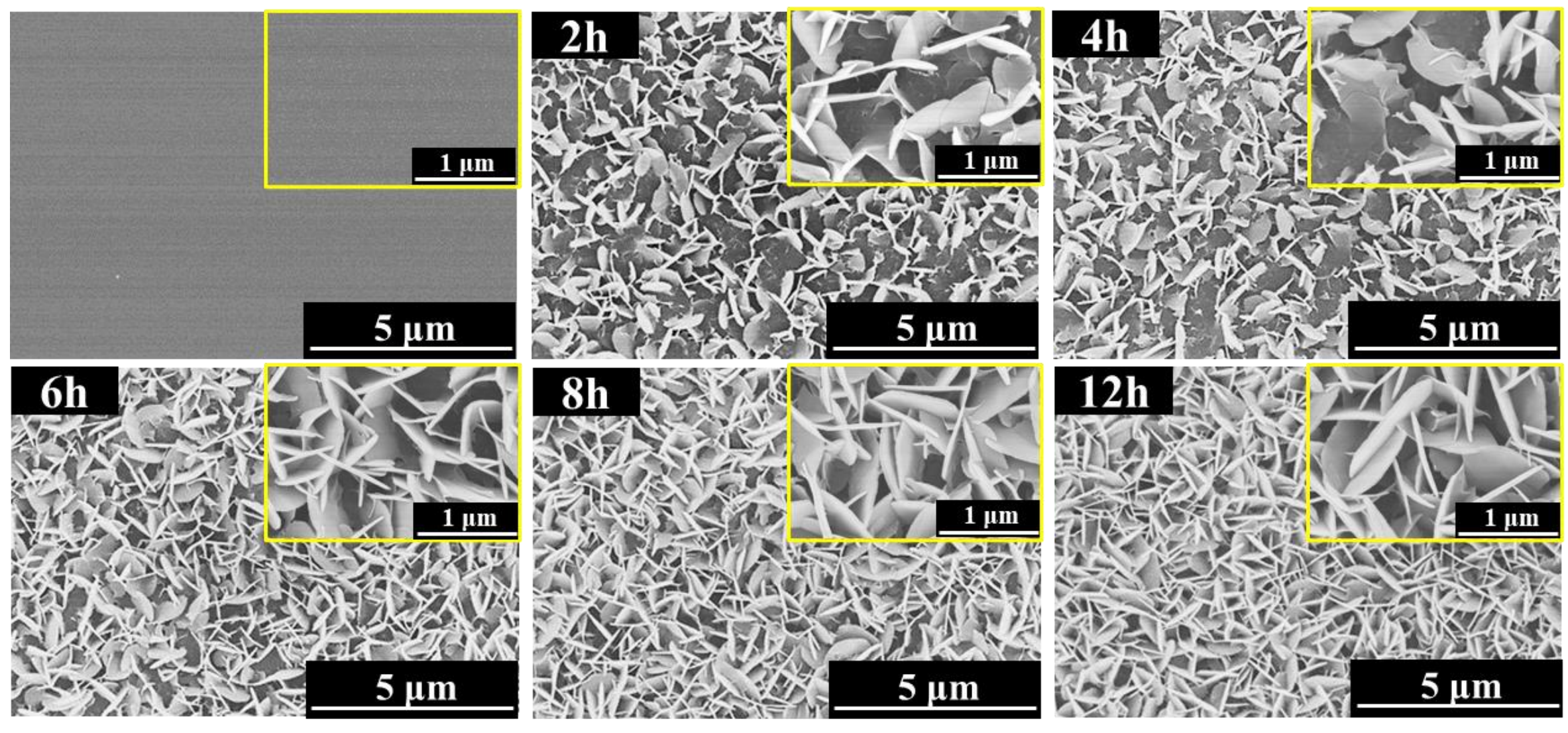
❖AFM

- Deposition time: 80 min

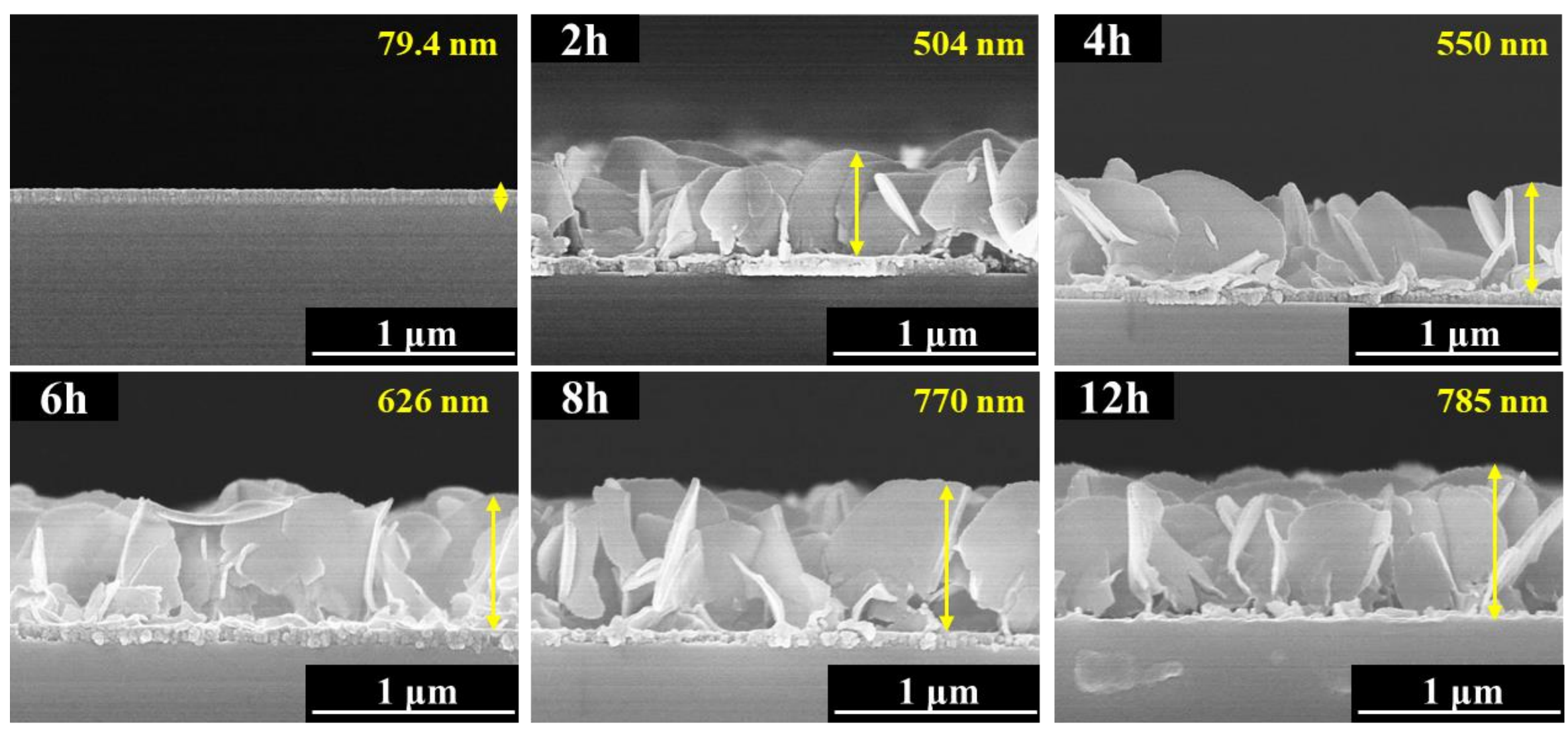


❖SEM

Different dipping times in DI water (Surface-section)



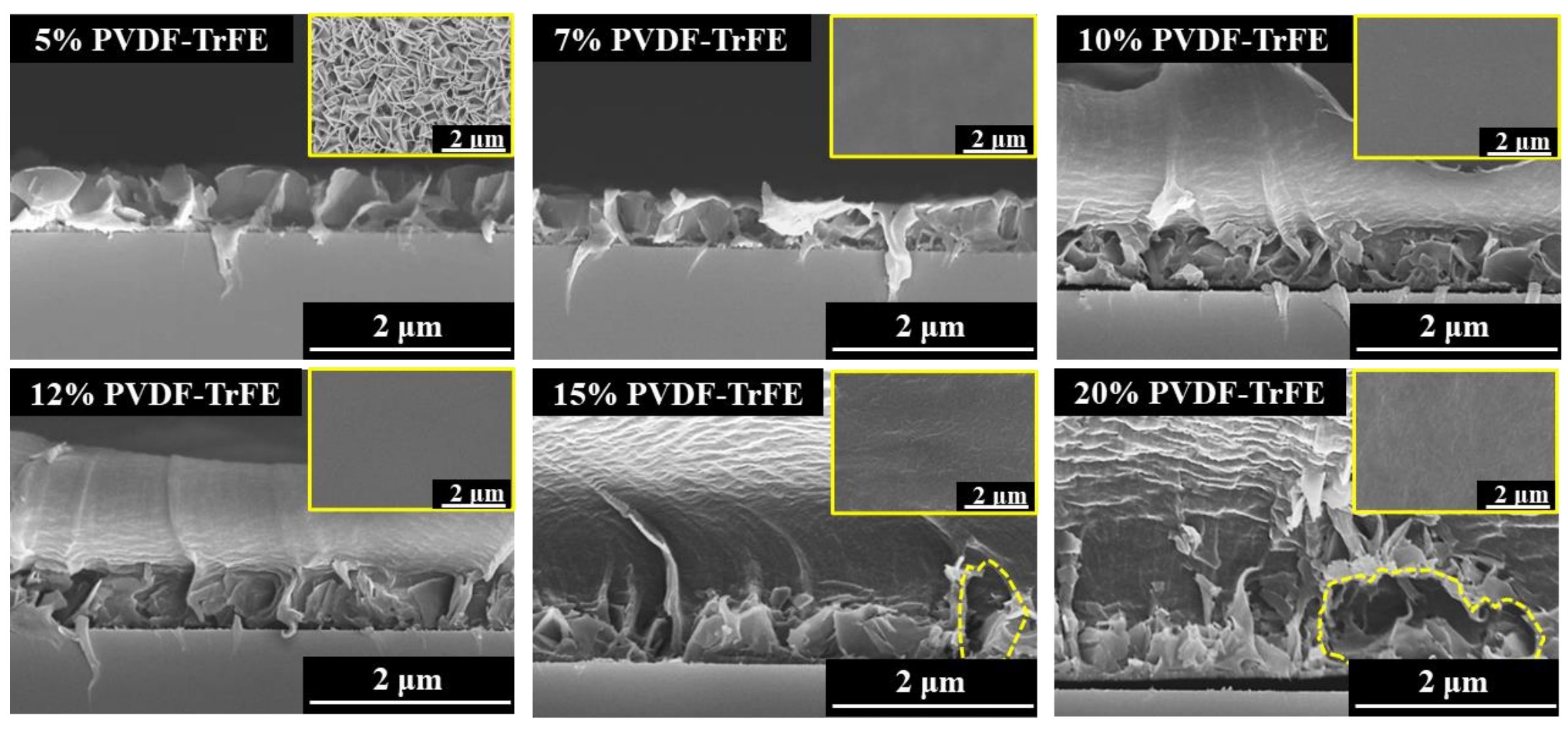
Different dipping times in DI water (Cross-section)



- Dipping time in DI water ↑

→ LDH density ↑, LDH thickness ↑, residual AZO film ↓

Different PVDF-TrFE concentrations (Surface & Cross-Section)

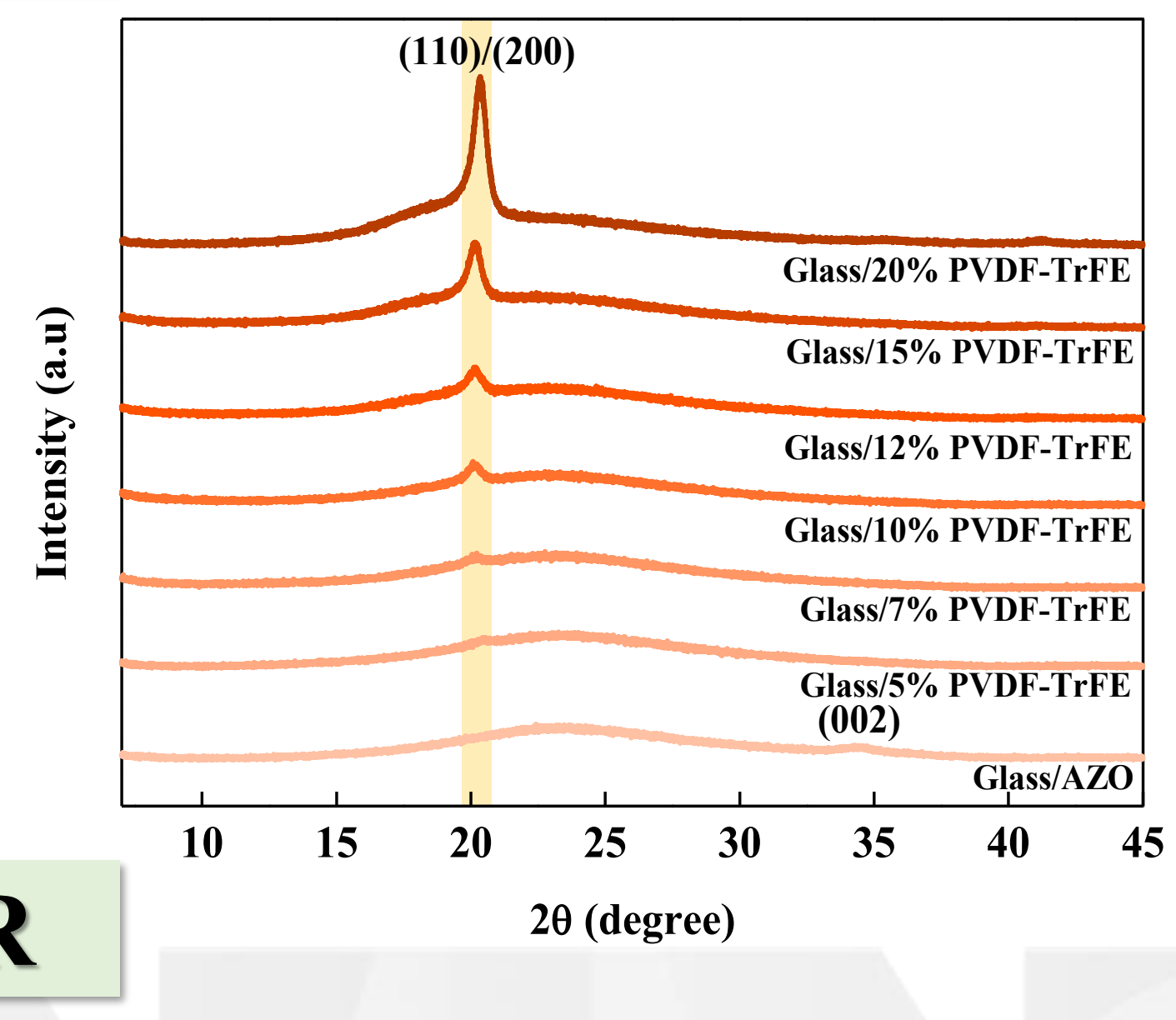


- PVDF-TrFE concentration ↓ → non-uniform surface coverage
- PVDF-TrFE concentration ↑ → solution viscosity ↑, limited penetration into LDH layer (porous region observed)

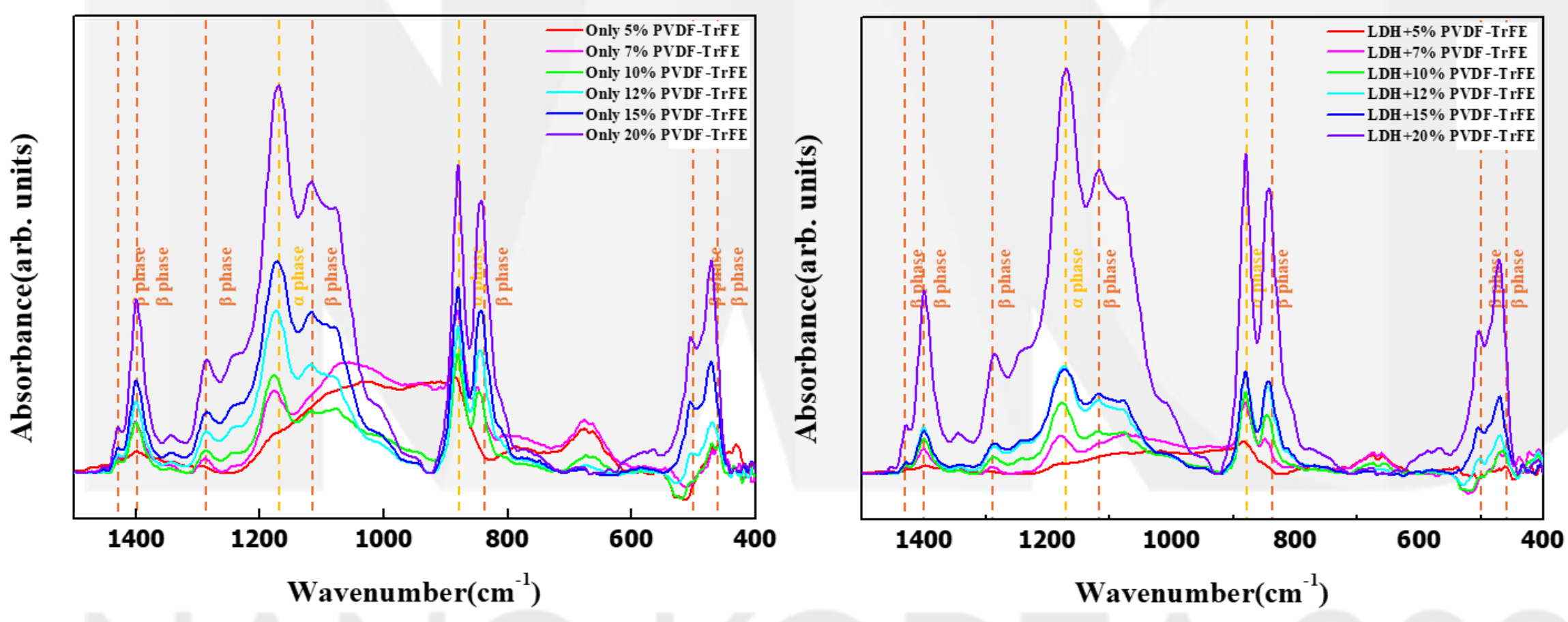
→ 10% and 12% PVDF-TrFE presented optimal morphology

❖XRD

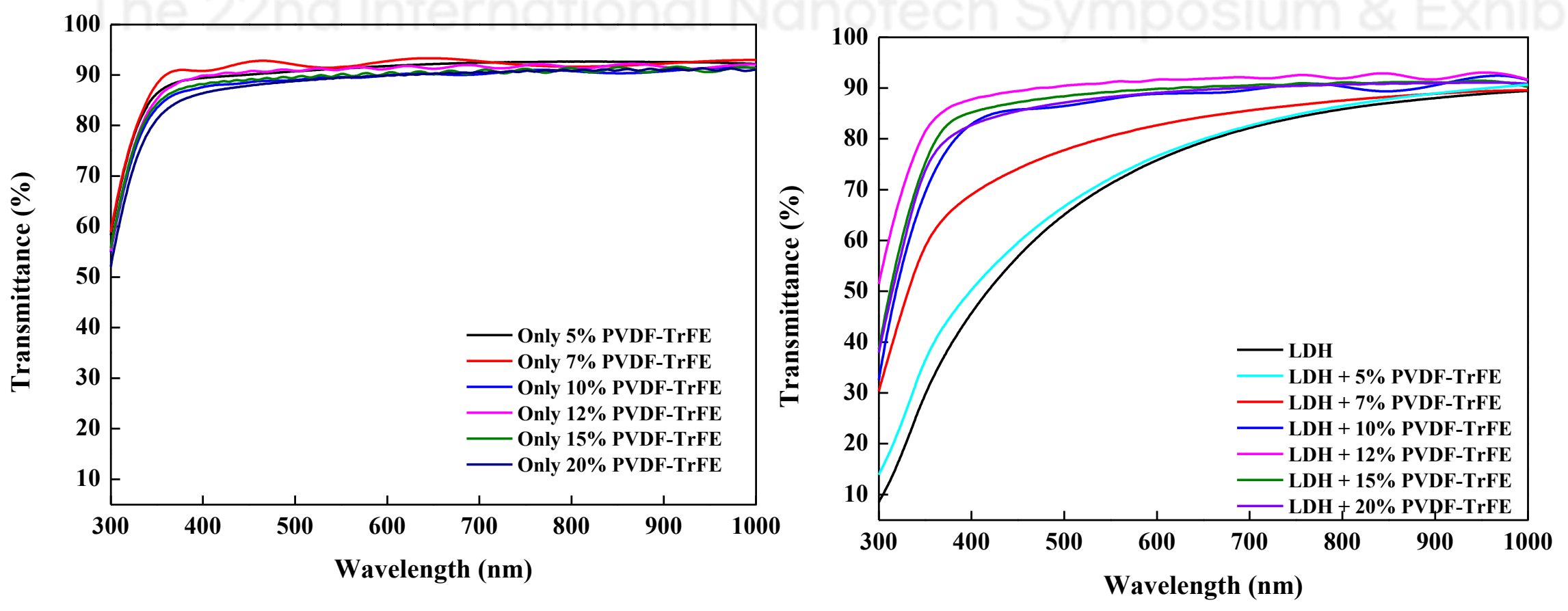
- PVDF-TrFE concentration ↑ → crystallinity ↑



❖FTIR



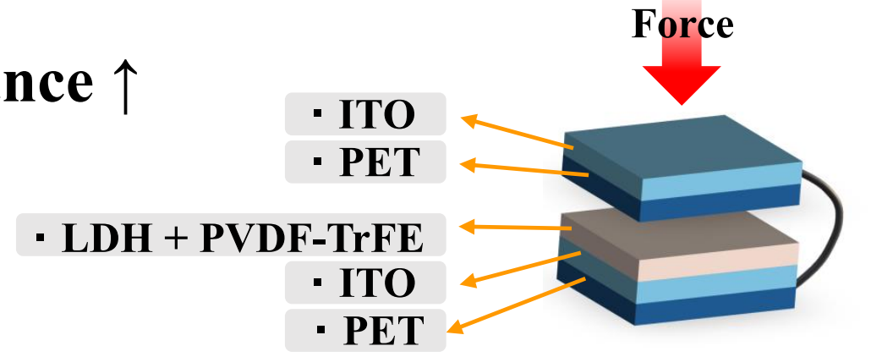
❖Transmittance

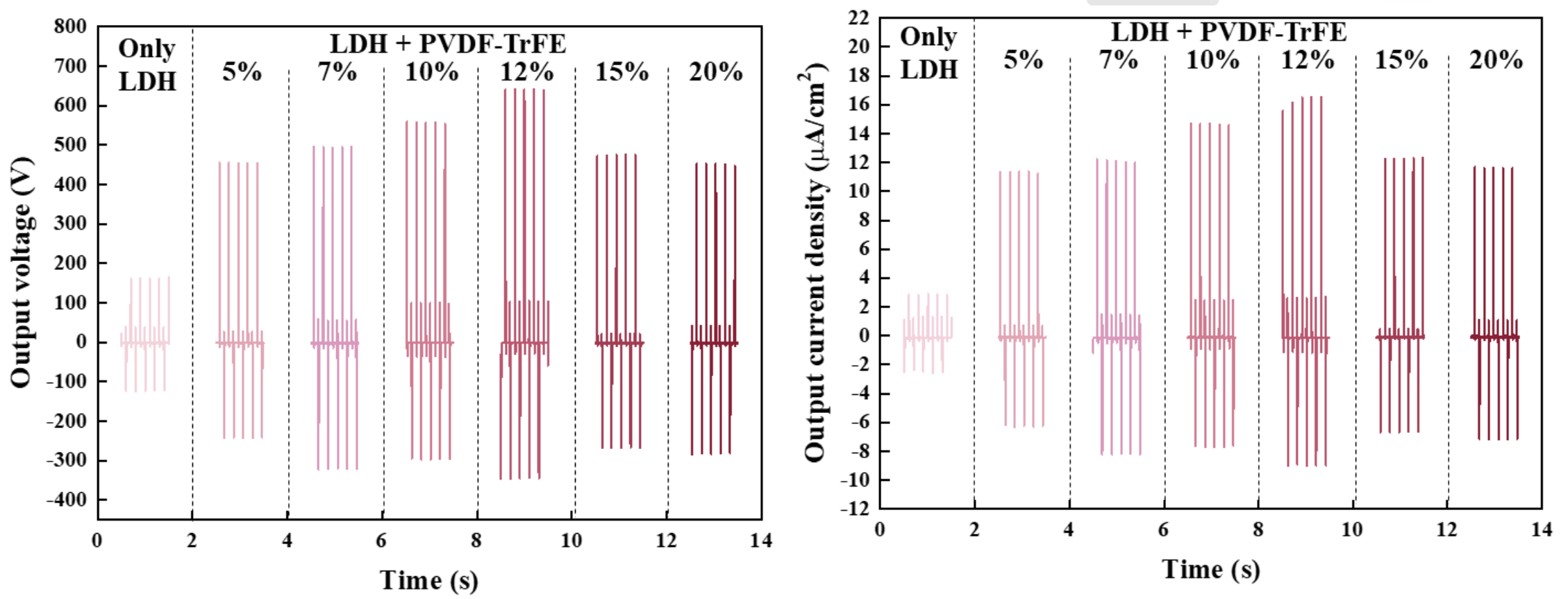


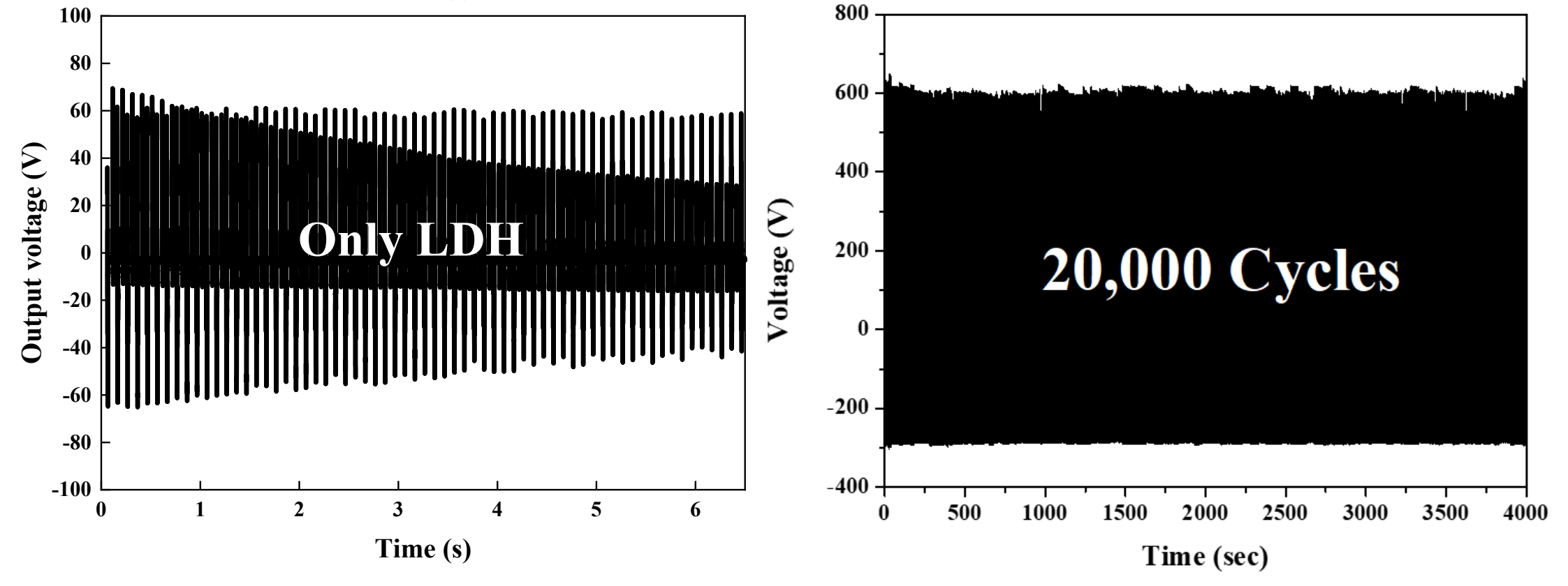
- PVDF-TrFE concentration ↑ & ↓ → Transmittance ↓
- 12% PVDF-TrFE → Transmittance ↑

❖TENG

- 5kg-5Hz

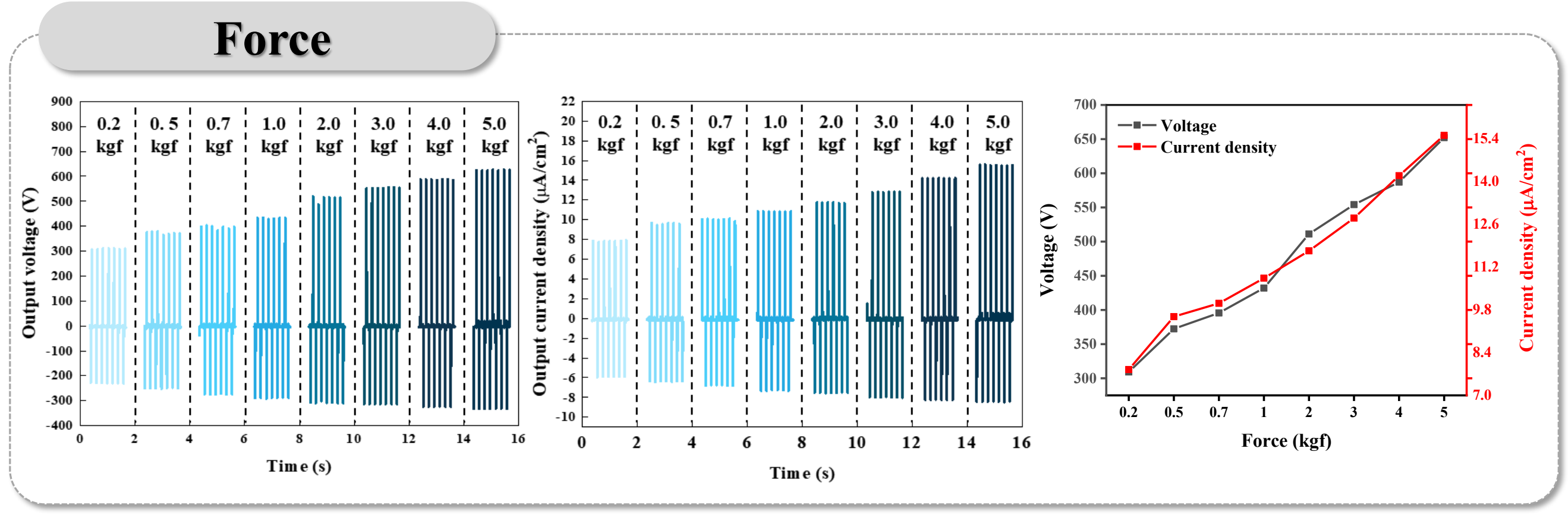




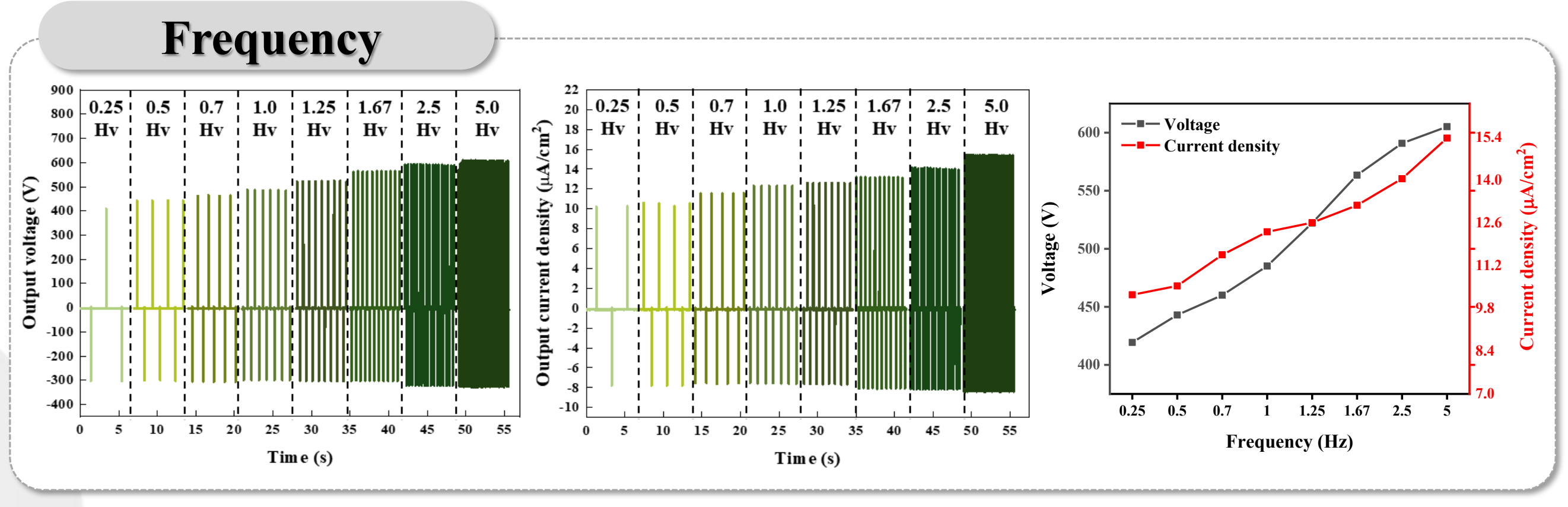


- 12% PVDF-TrFE sample → output voltage & current density ↑
- PVDF-TrFE coating enhances the long-term stability

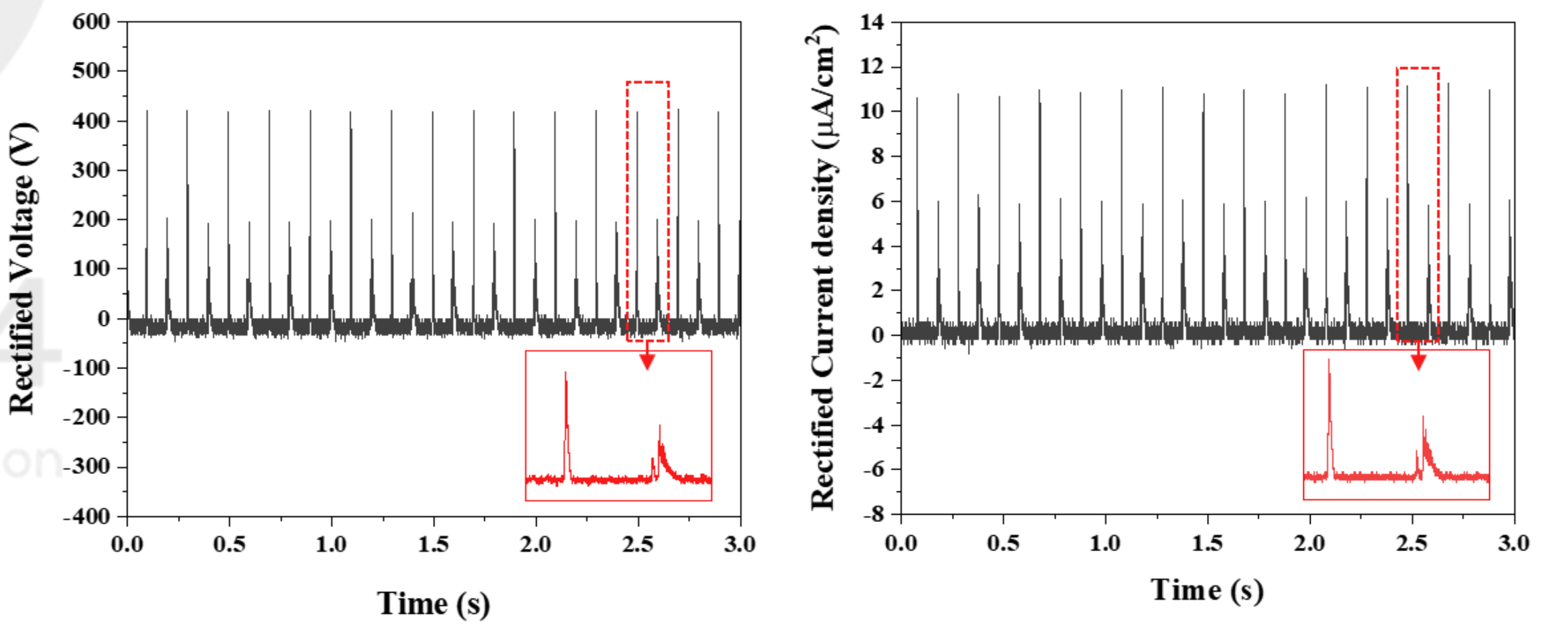
Force



Frequency

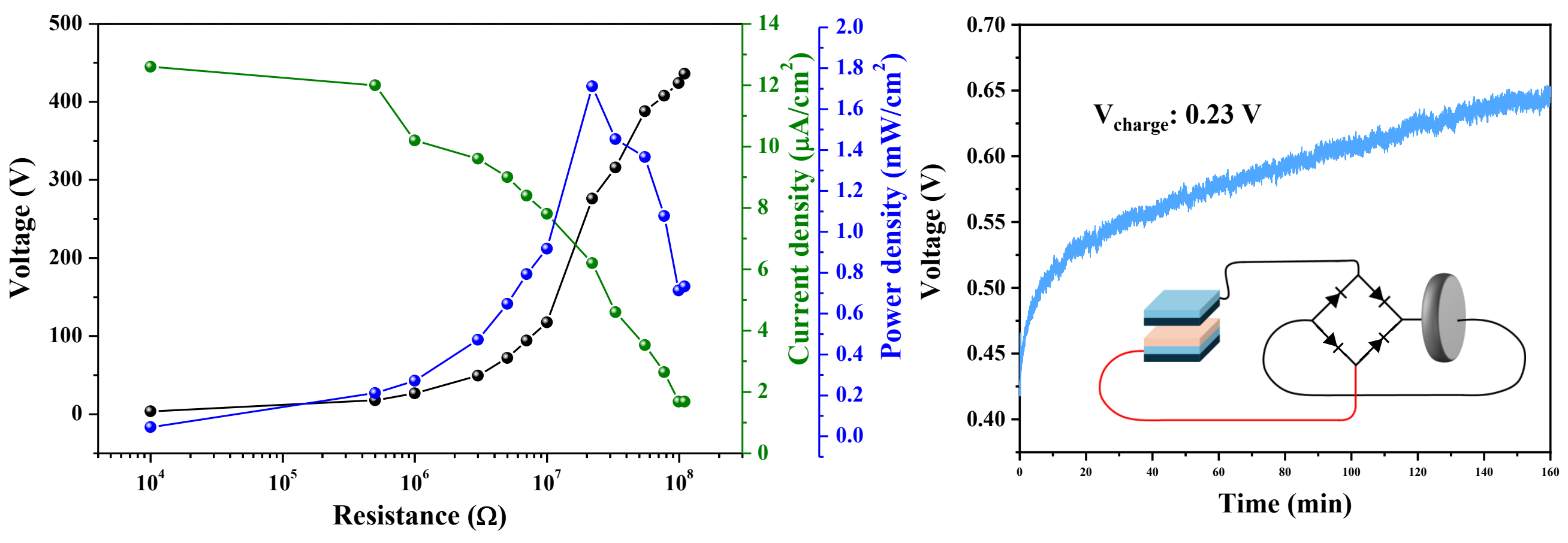


❖Rectifier



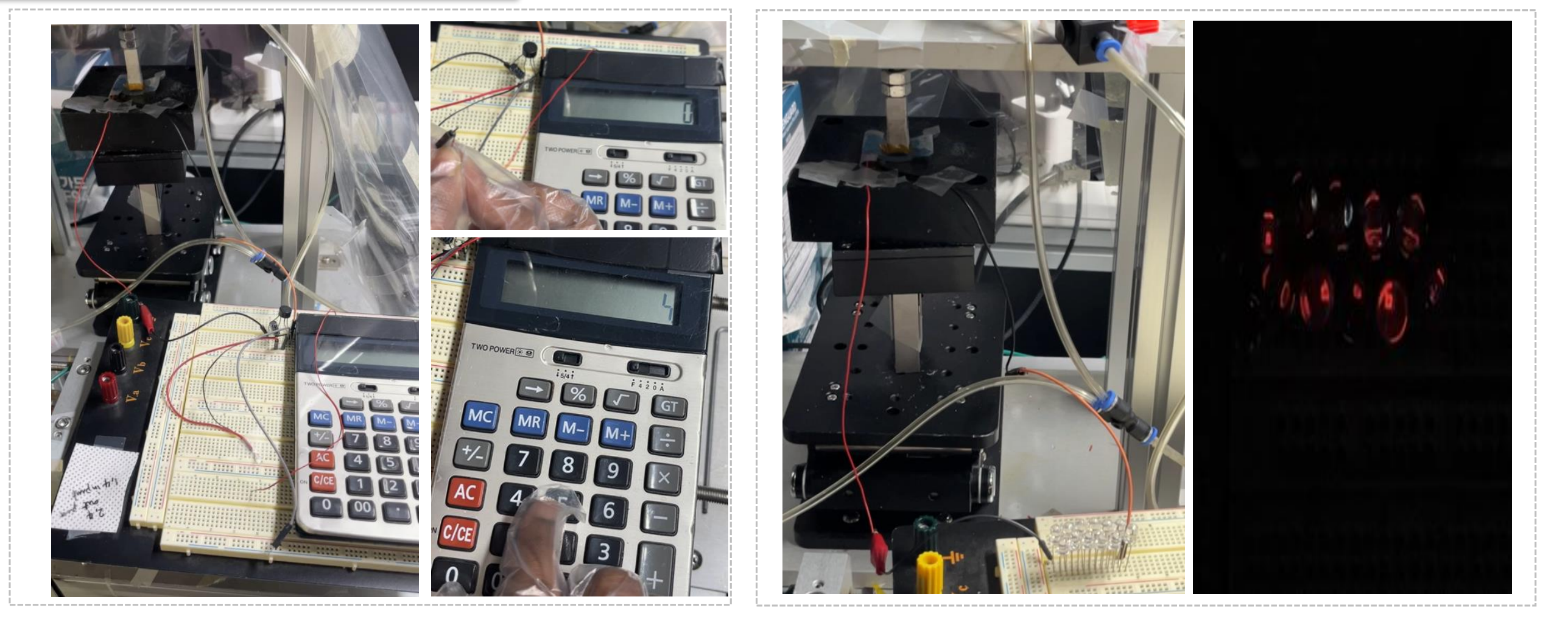
- AC signals from the TENG were converted to DC using a bridge rectifier and stored in a capacitor

❖Supercapacitor charged by TENG



- Max. power density of 1.71 mW/cm² at matching load of 22 MΩ
- Self-charging power source: Zn ion SC charged upto 0.23 V in 160 min by the TENG

❖Applications



- The TENG device powered a calculator and lit LEDs, showing its potential for daily-use self-powered applications

Conclusions

- ➢ The optimized LDH growth (12 h) and PVDF-TrFE concentration (12%) effectively enhanced the triboelectric output performance and stability of LDH-PVDF TrFE based TENGs.
- ➢ These improvements originated from the synergistic contribution of flexoelectric and ferroelectric polarization, leading to superior charge transfer.
- ➢ This strategy provides a promising route toward flexible, self-powered, and high-performance energy harvesting devices for next-generation wearable electronics.