

Perovskite – Polymer Composites for Ambient Energy Harvesting



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Contents

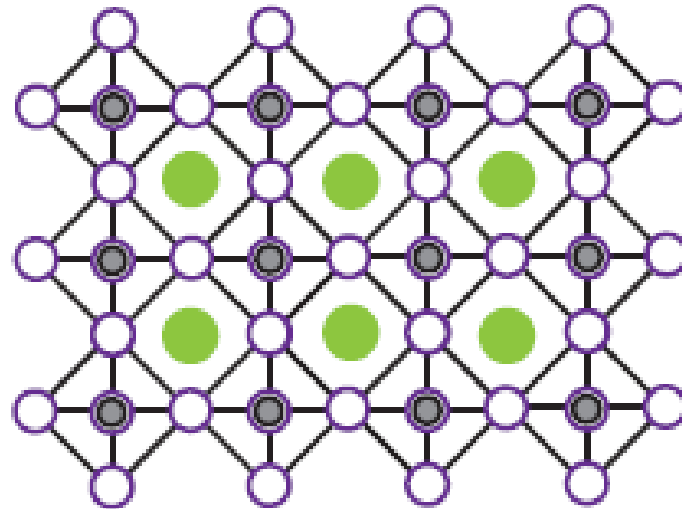
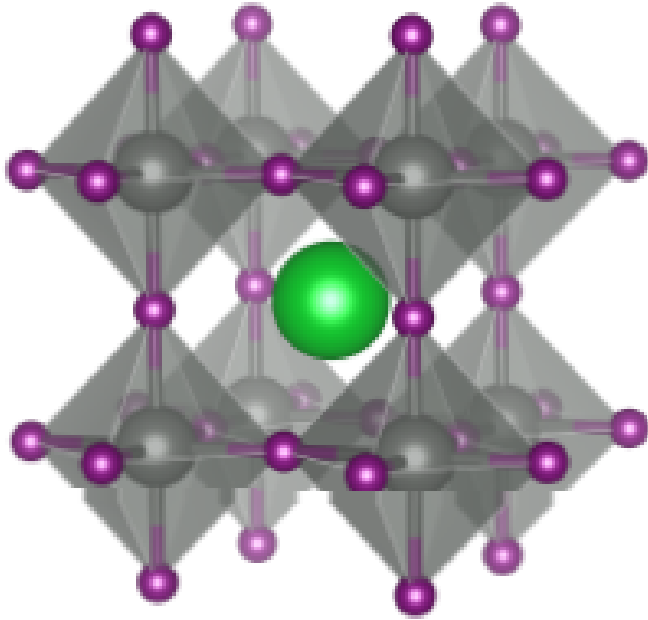


- Polymer – Perovskite composites for stable light emission
- Piezo/triboelectric nanogenerators based on polymer – perovskite composites
- Moisture to electricity conversion using polymer - perovskite composites

Polymer Perovskite Composite Films



3D perovskite - ABX_3



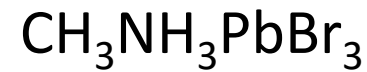
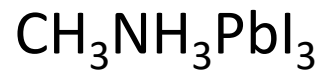
Interesting Material properties:

- High Crystallinity at low temperatures
- High optical absorption coefficient
- Excellent charge carrier transport (crystallinity, diffusion length, carrier mobility)
- Promising device parameters: (High V_{oc} of $>1.1V$)

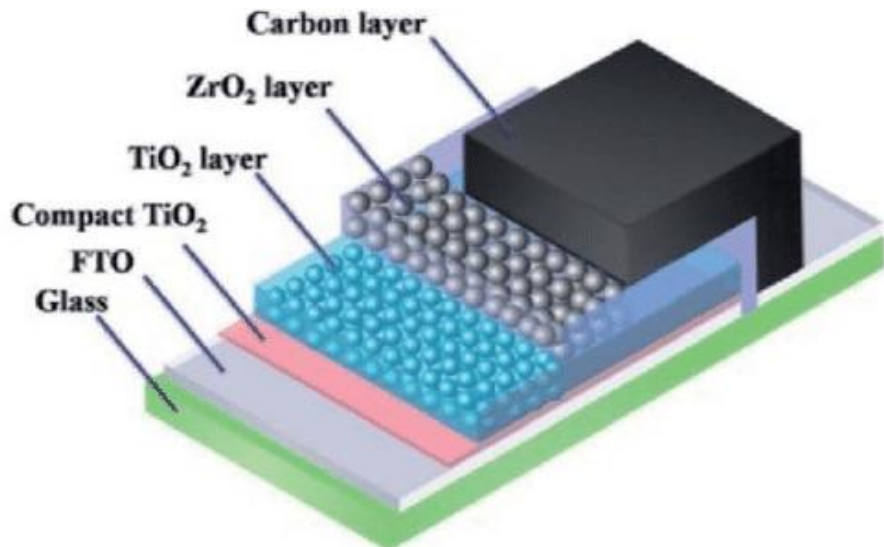
Polymer Perovskite Composite Films



In Hot and humid Mumbai conditions within a few days



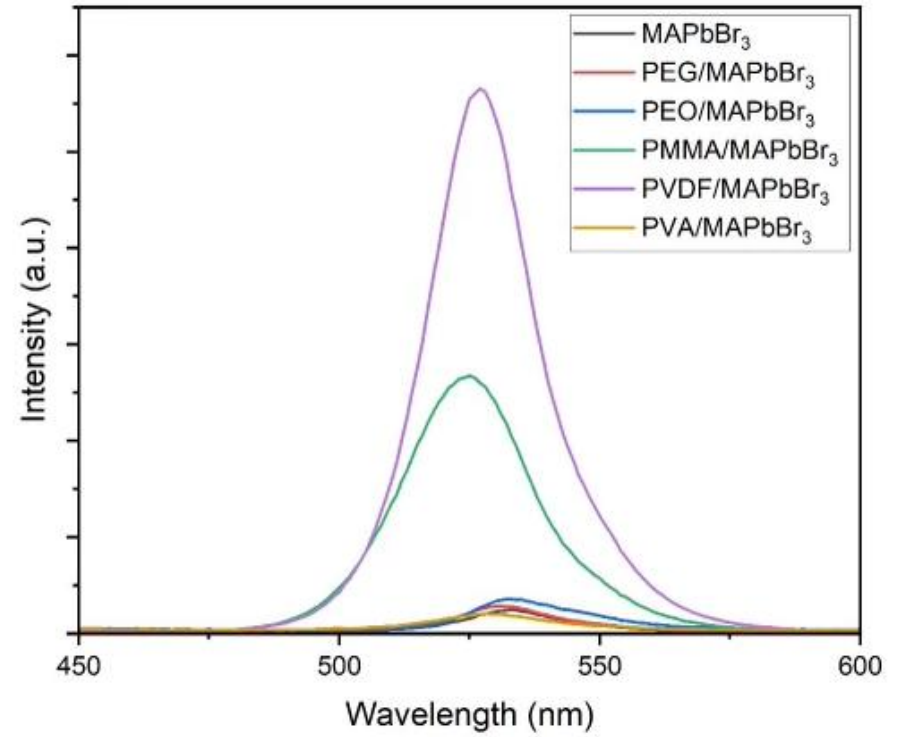
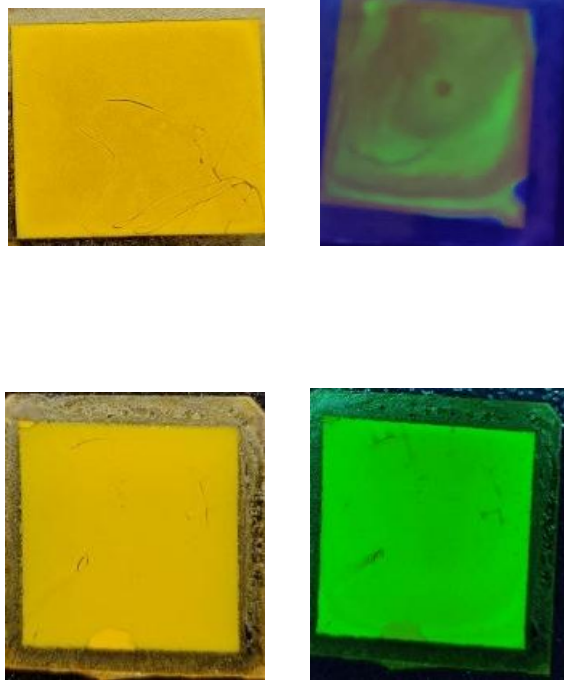
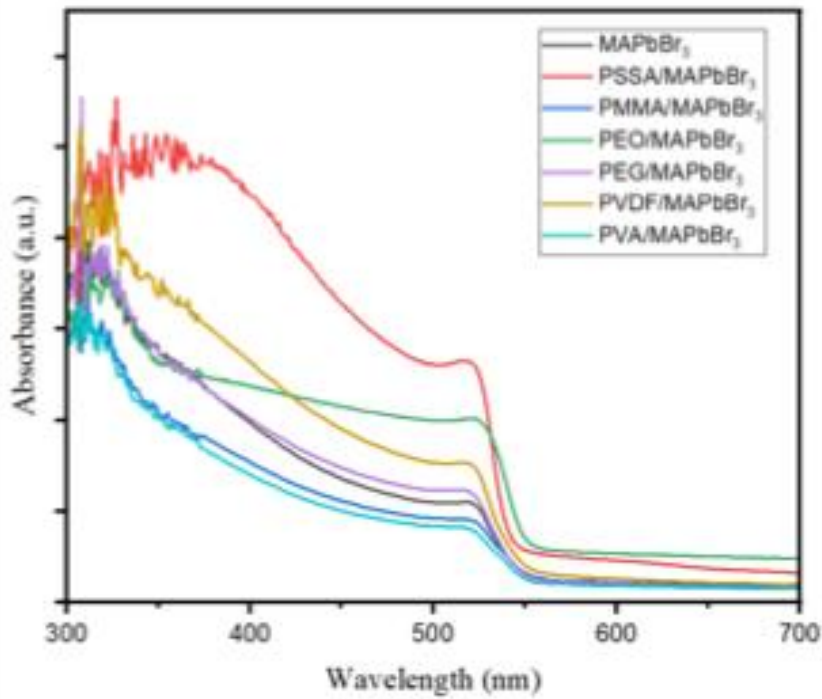
Average annual relative humidity in Mumbai is 76%



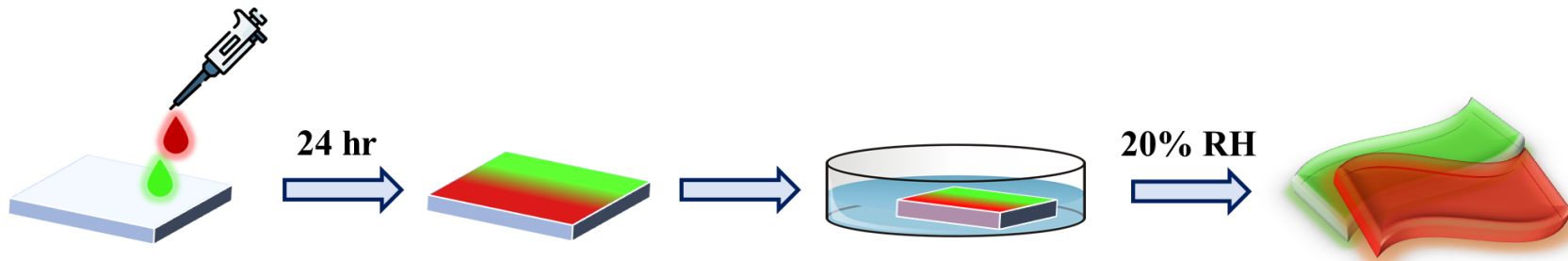
PMMA Polymer encapsulation is not very efficient

- Can we use alternative polymers which can be used as encapsulant?

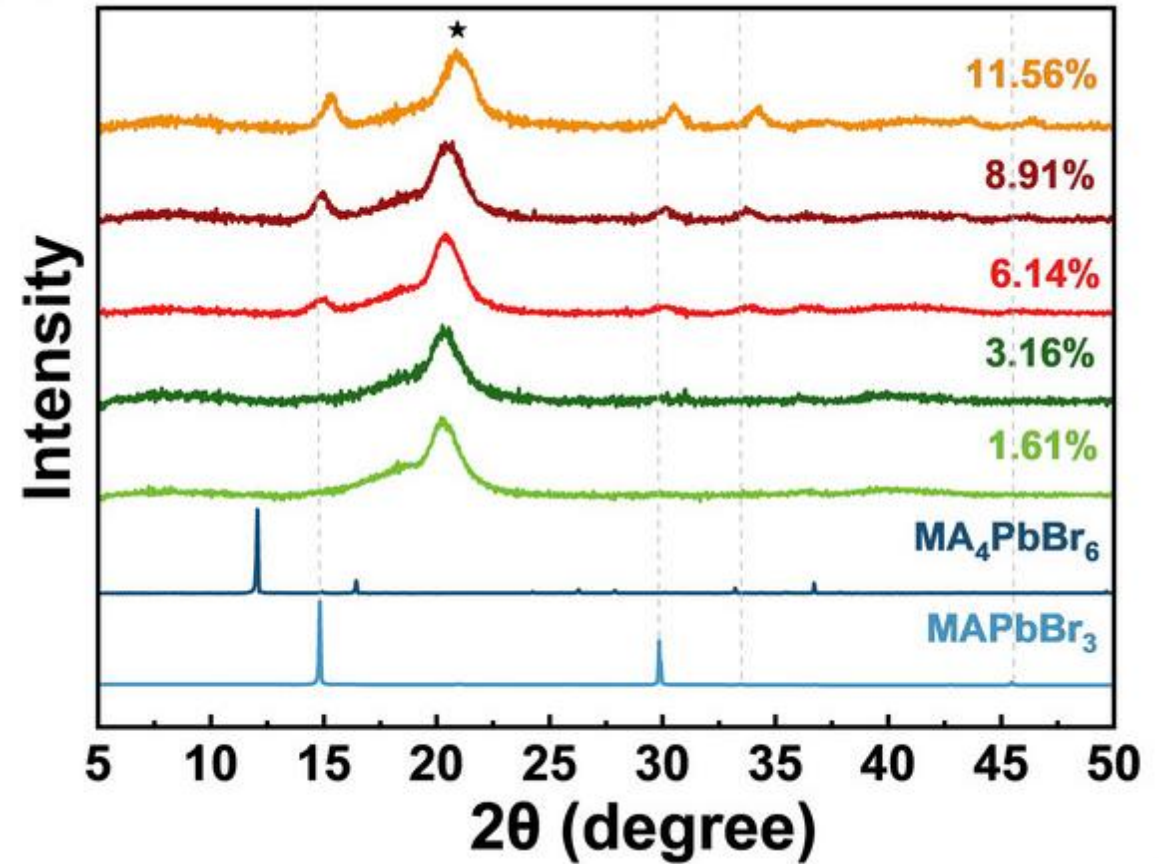
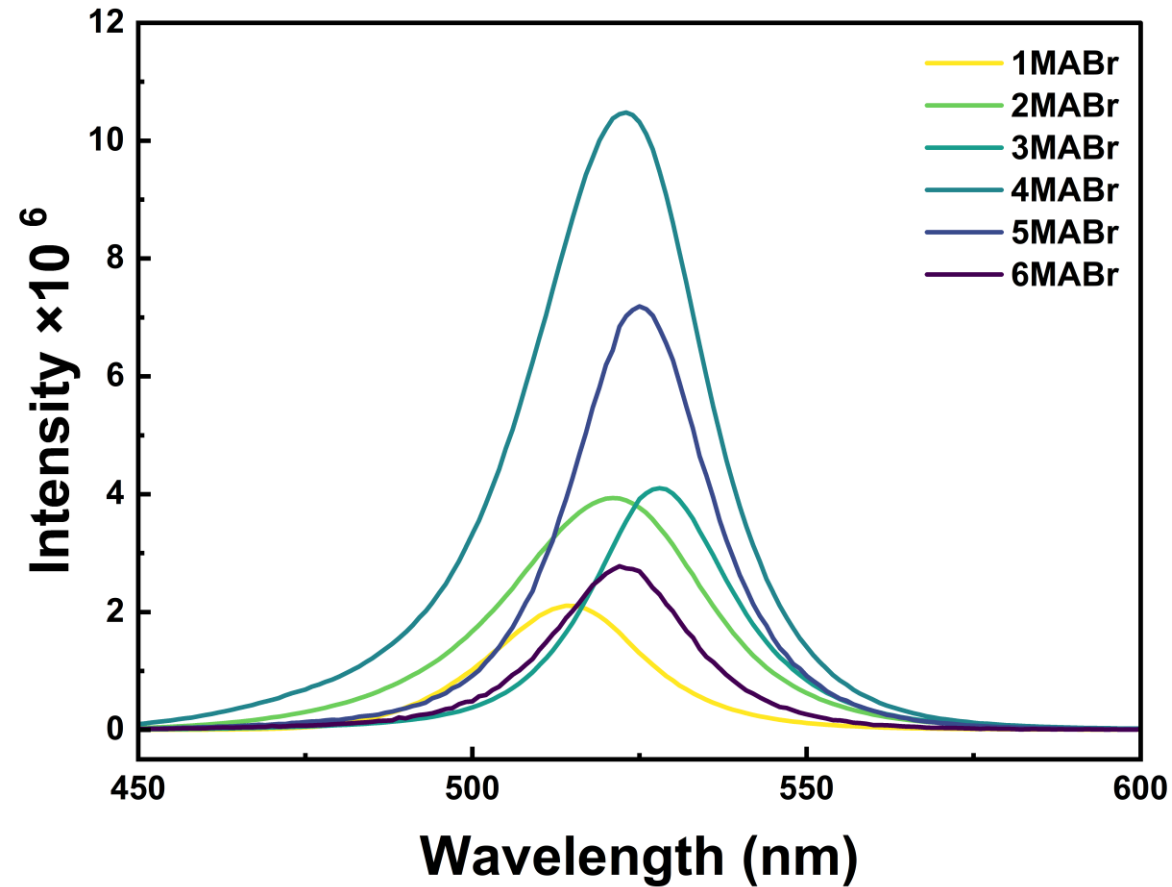
Polymer Perovskite Composite Films



Polymer PVDF show much higher PL intensity than bare MAPbBr₃ films



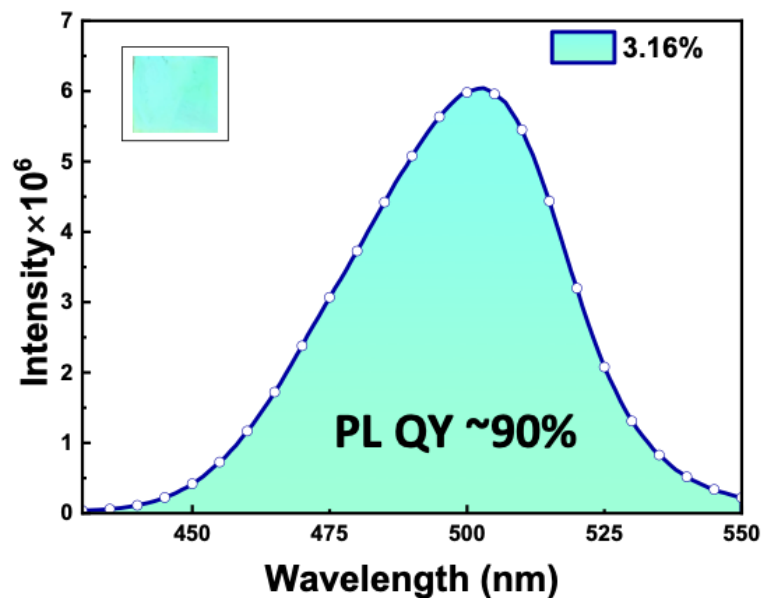
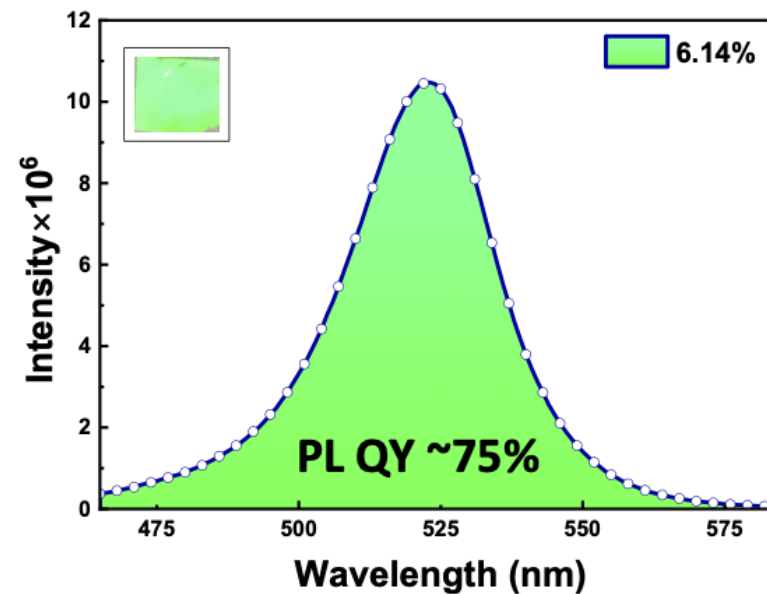
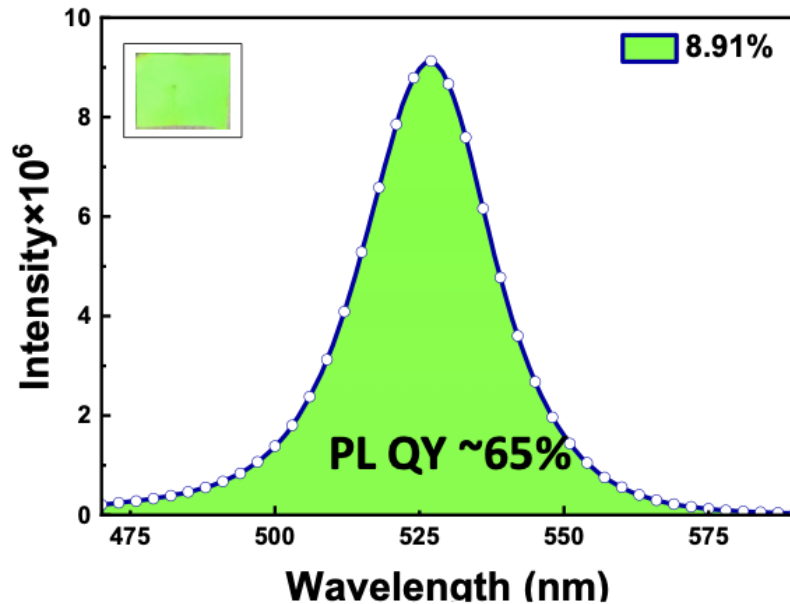
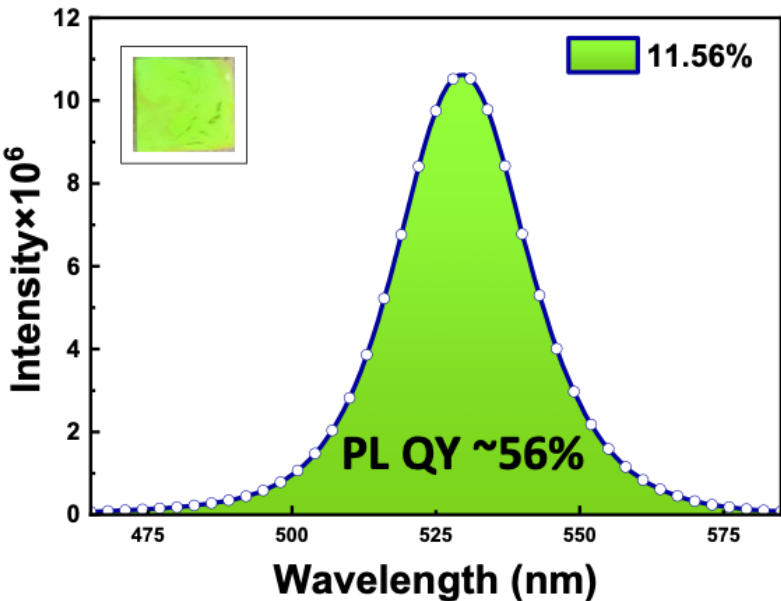
Polymer Perovskite Composite Films



Excess MAX increased the PL intensity and PL QY

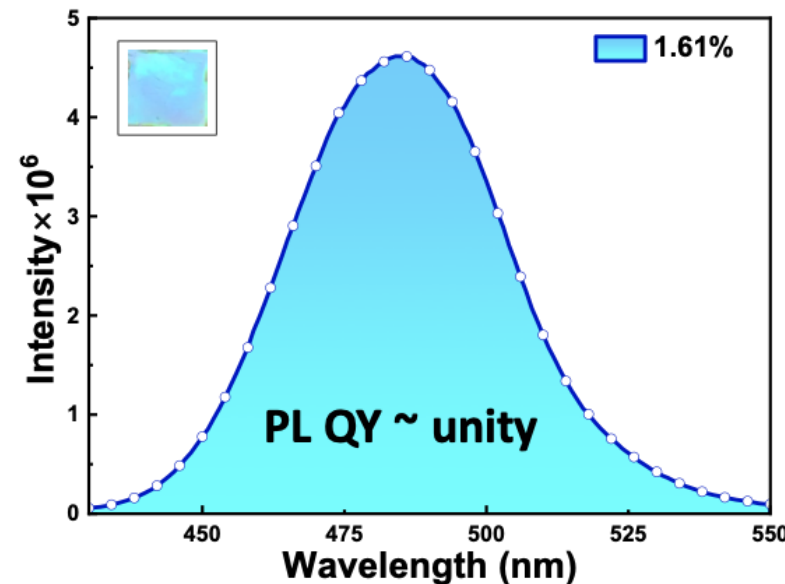
4 times excess MAX resulted in highest among all. Probable influence of MA_4PbBr_6

Polymer Perovskite Composite Films

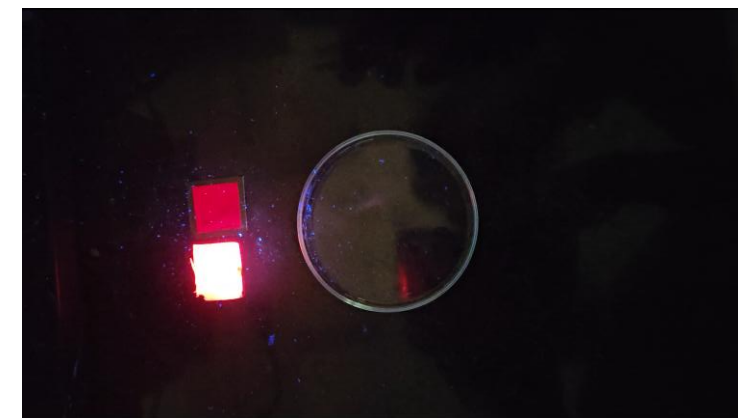
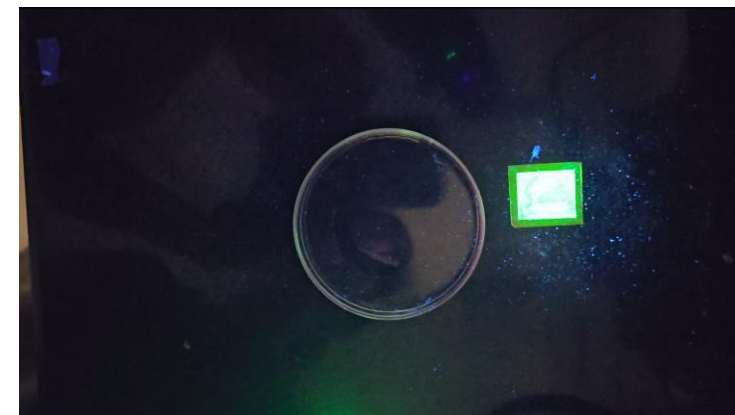
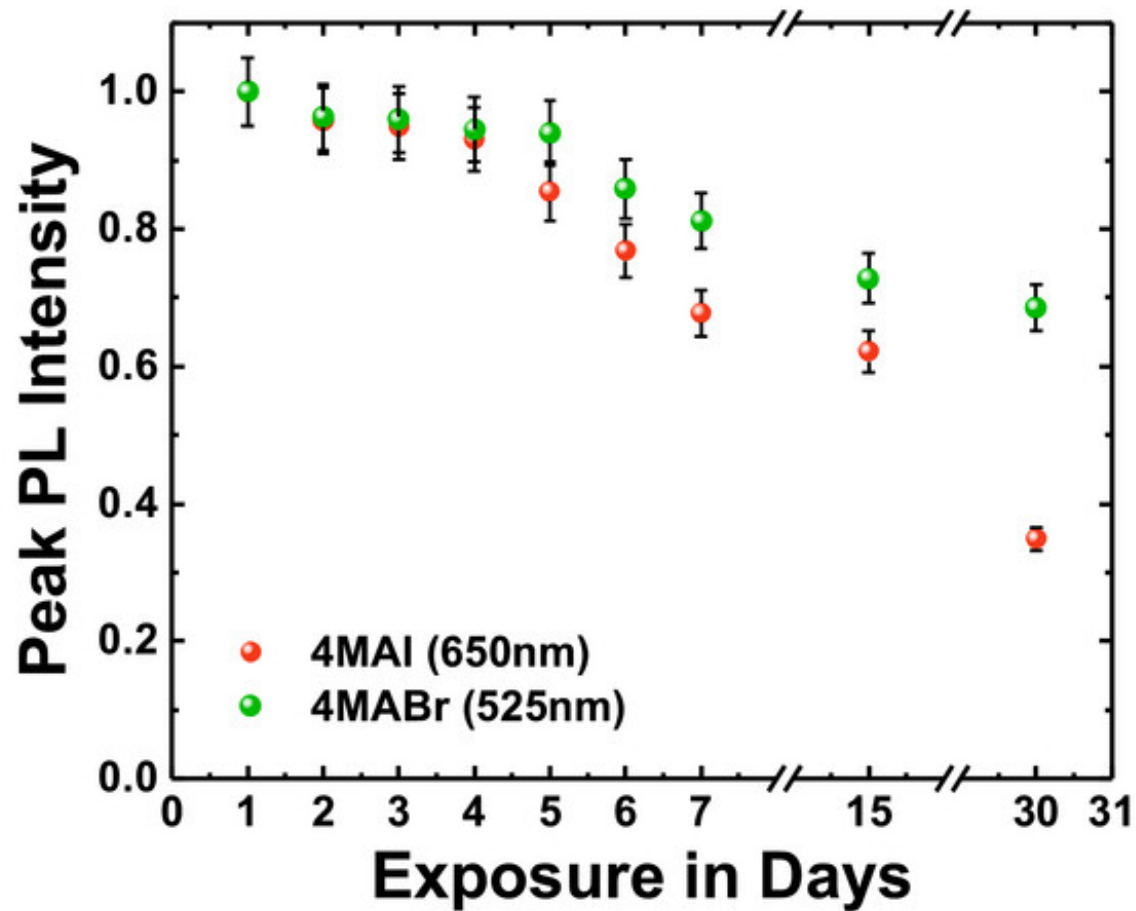
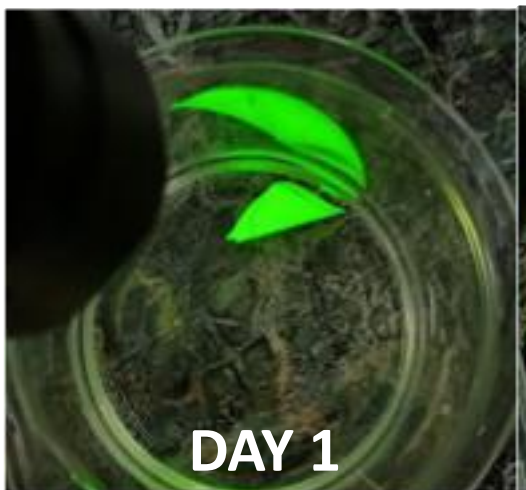


PL QY increased with lower perovskite concentrations

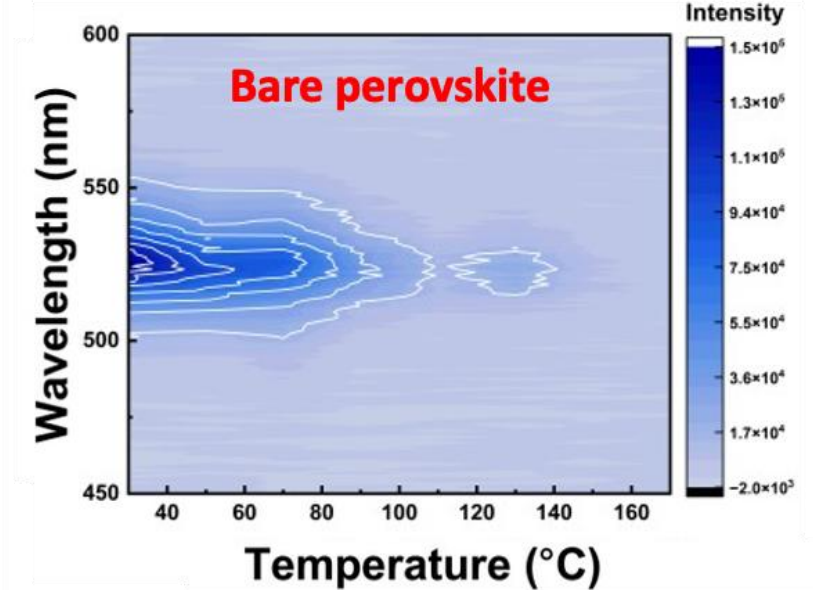
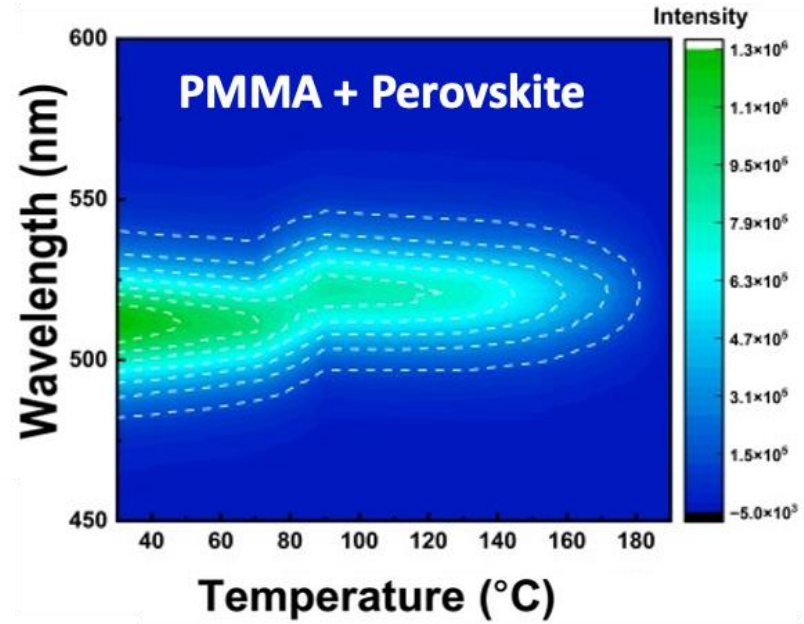
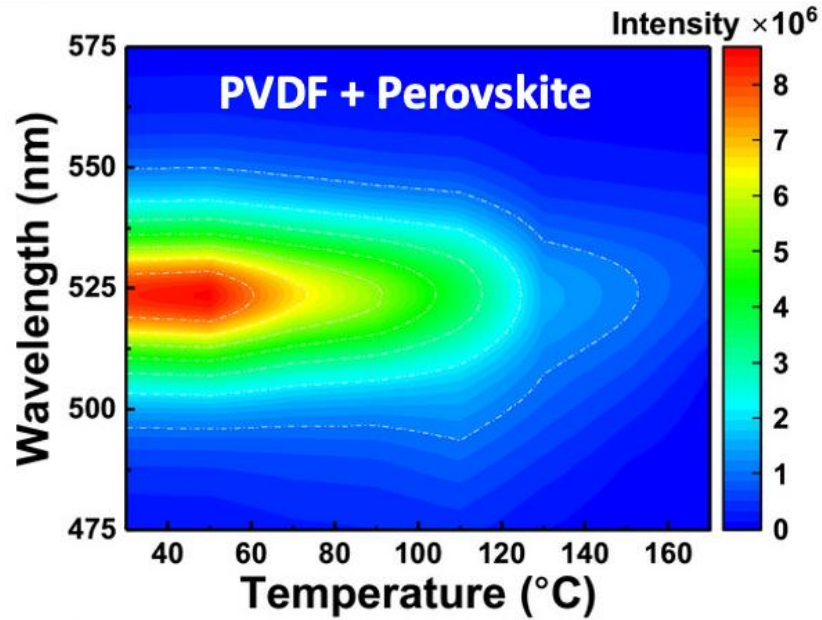
Though PLQY is less for 11% Films, they are very bright to naked eye compared to bare films



Polymer Perovskite Composite Films



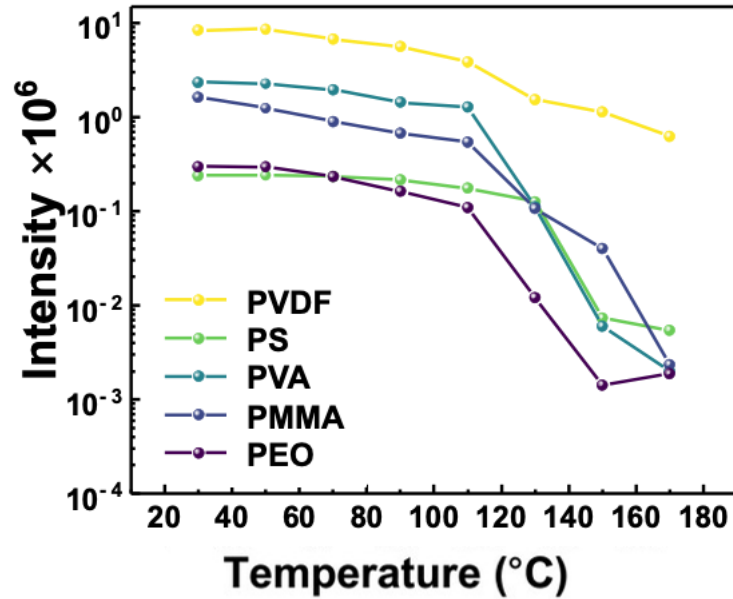
Polymer Perovskite Composite Films



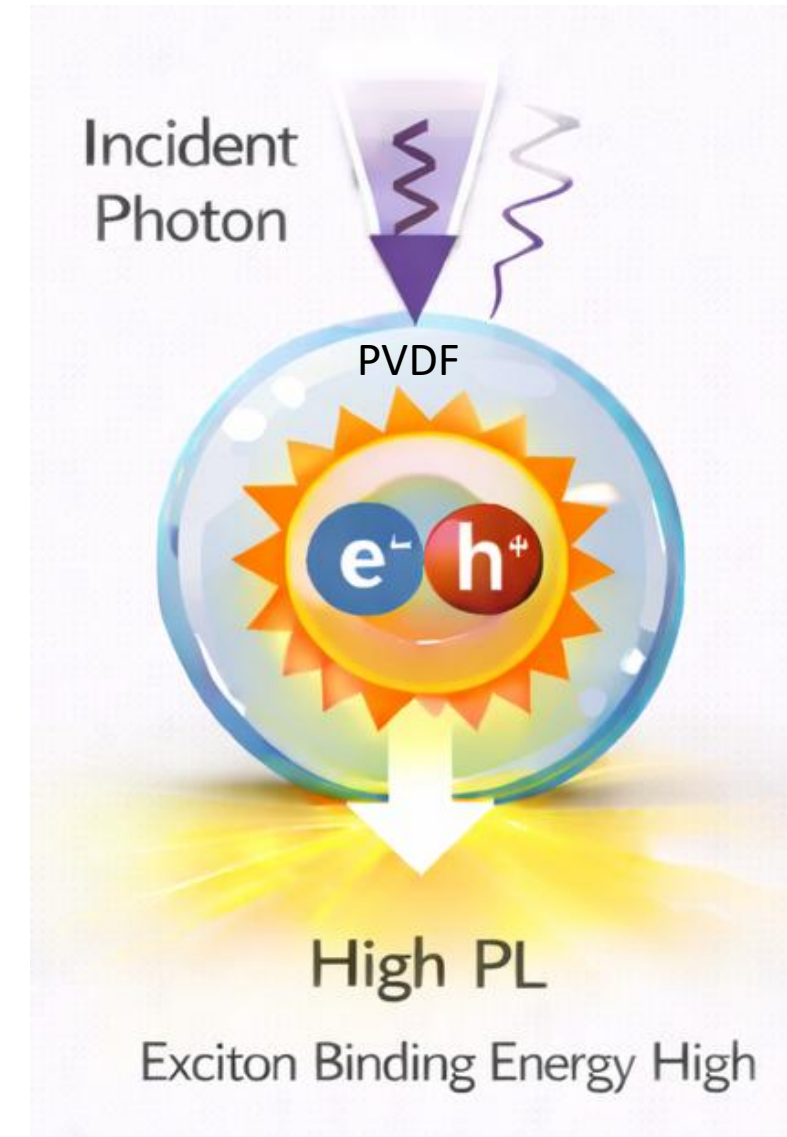
Compared to PMMA, PVDF showed less thermal quenching of Photoluminescence



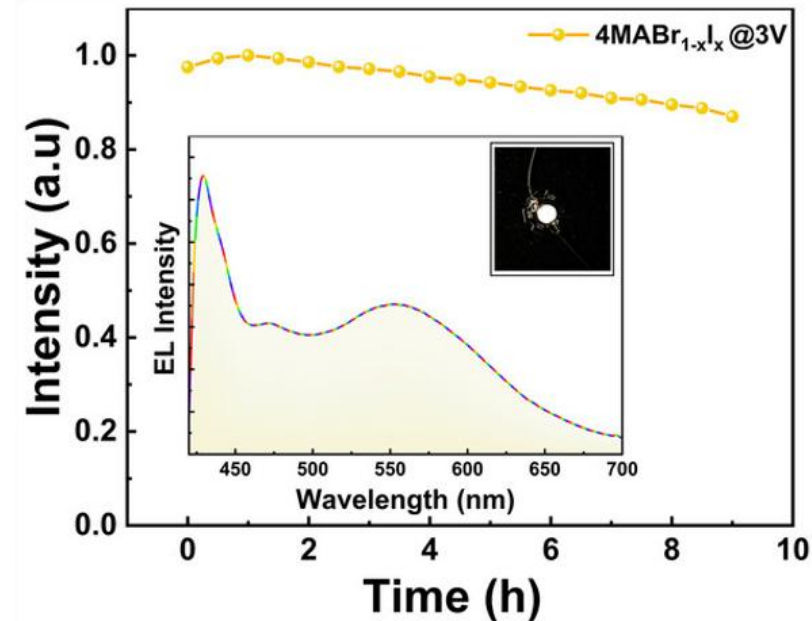
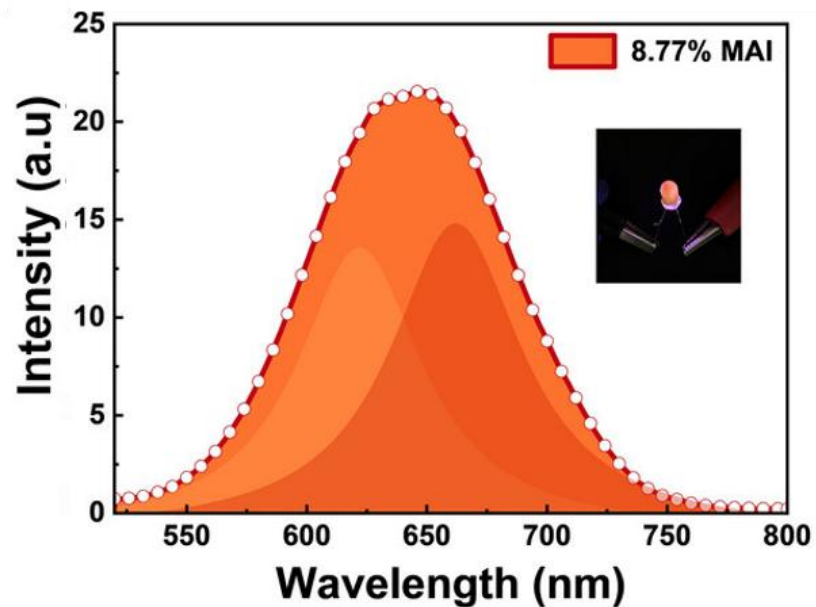
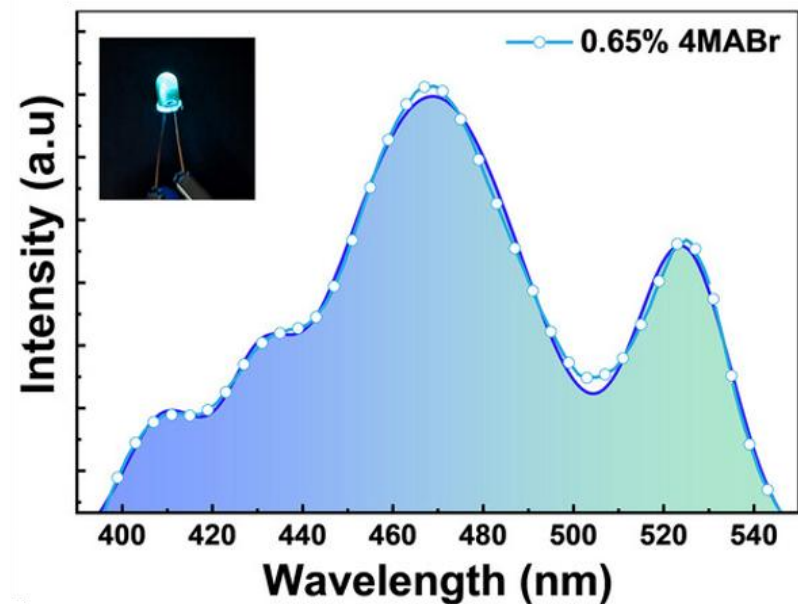
Polymer Perovskite Composite Films



Dielectric confinement of the perovskite with PVDF enhanced the stability of the perovskite

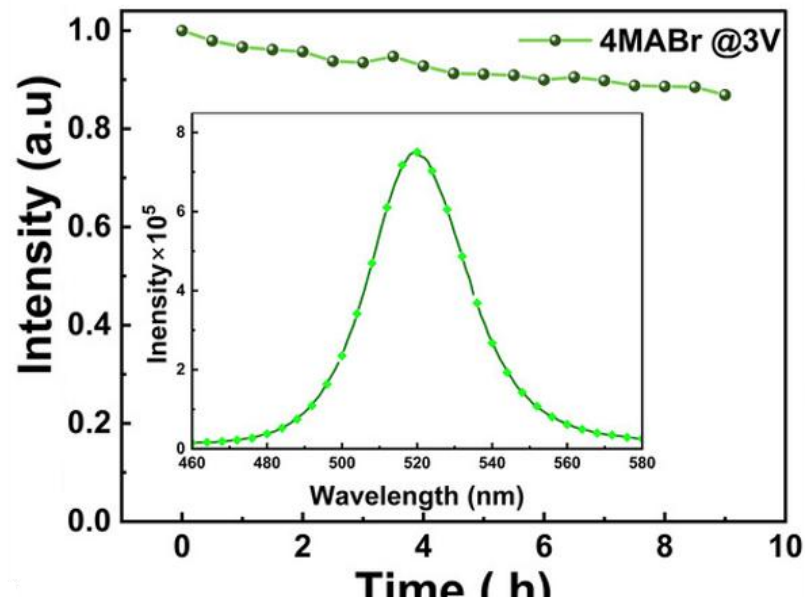


Polymer Perovskite Composite Films

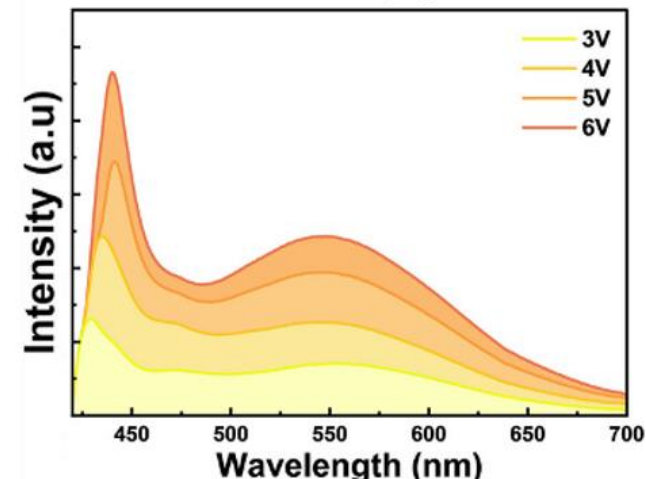


High Brightness of 3×10^8 Cd/m² at 3V for the green emitting devices

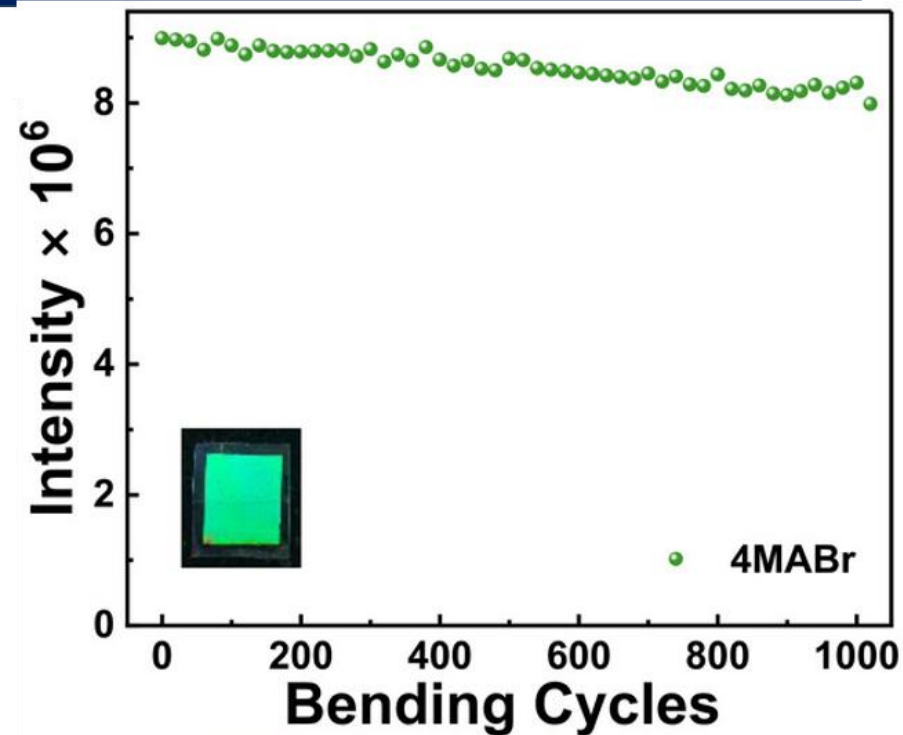
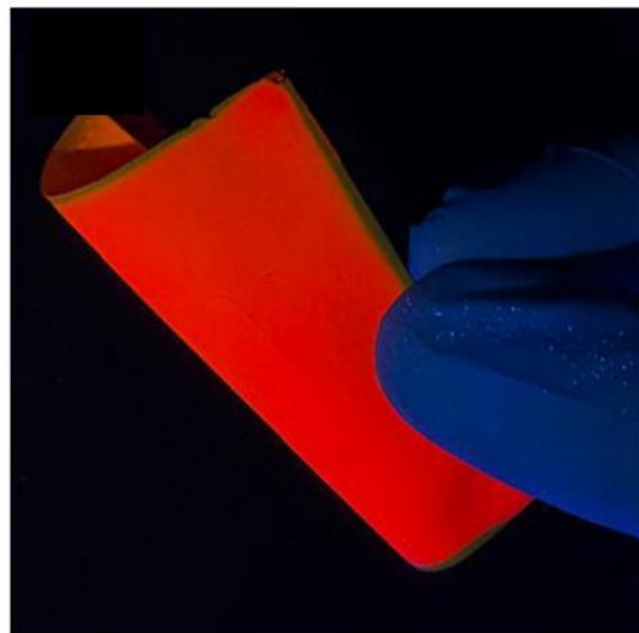
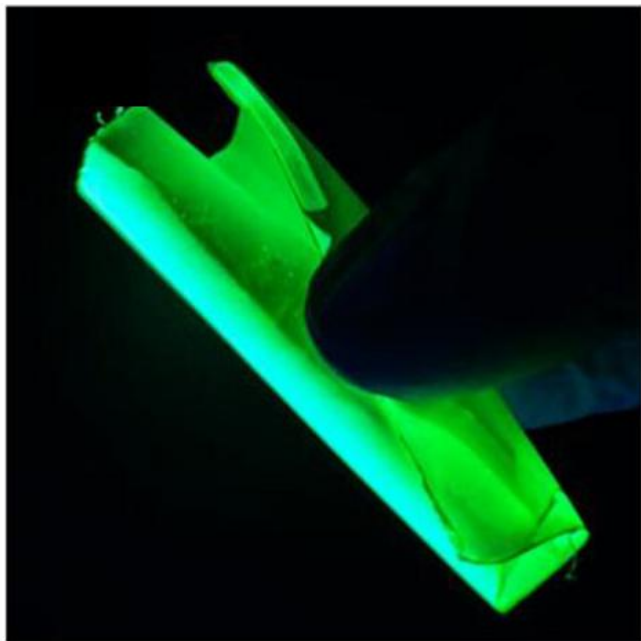
Brightness of 8.5×10^7 Cd/m² for white light emitting devices



Not much change in the emission even after continuous operation for 10 hrs

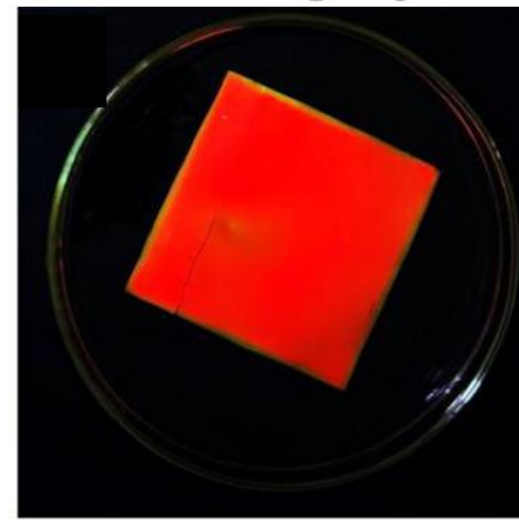
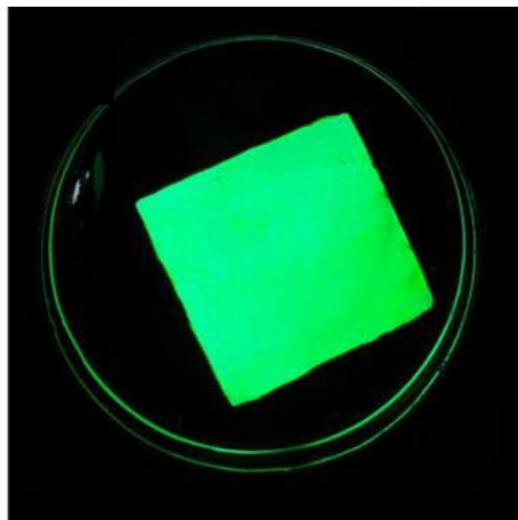


Polymer Perovskite Composite Films

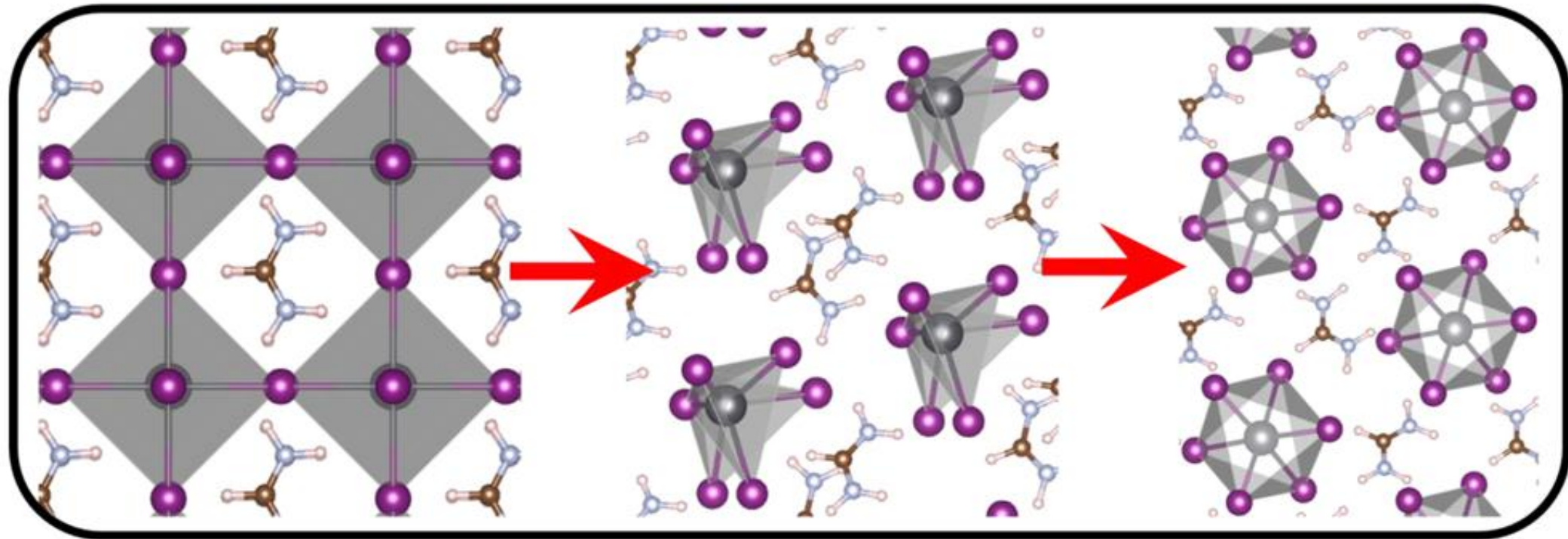


Flexible thin films can be prepared

No change in the PL with bending or dipping in water

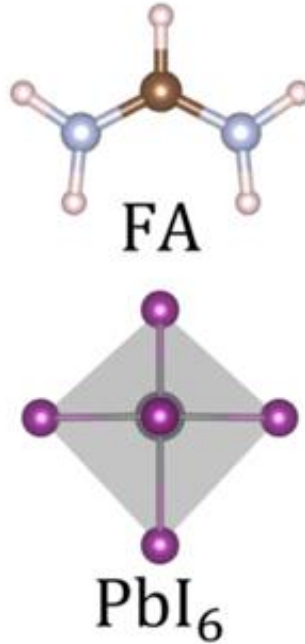


Polymer Perovskite Composites For Energy Harvesting



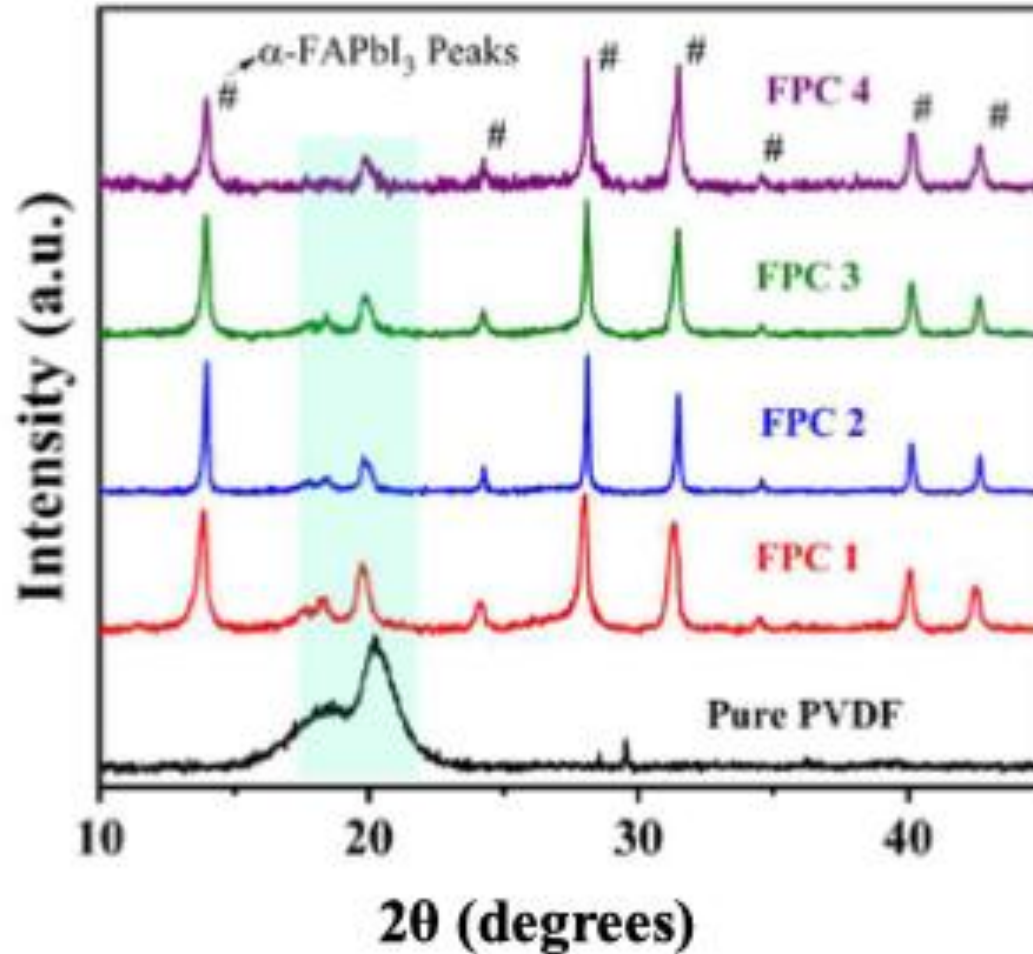
α - phase

δ - phase



FAPbI₃ unstable in the black perovskite phase (α -phase)

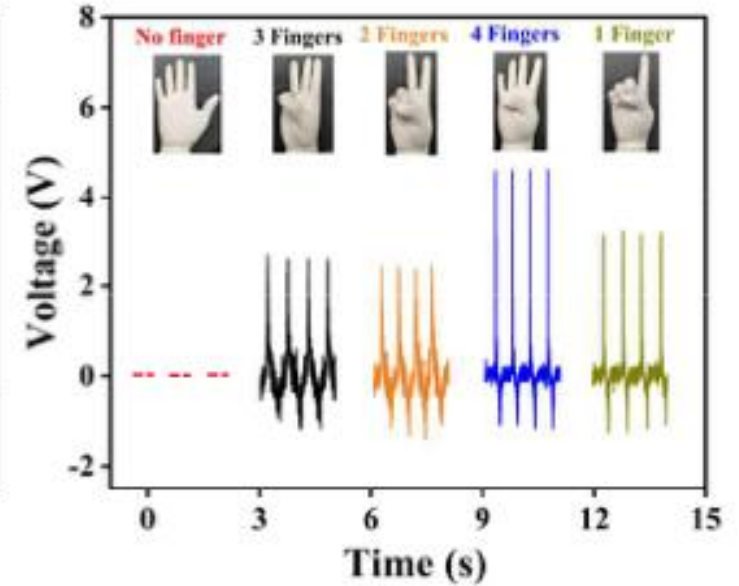
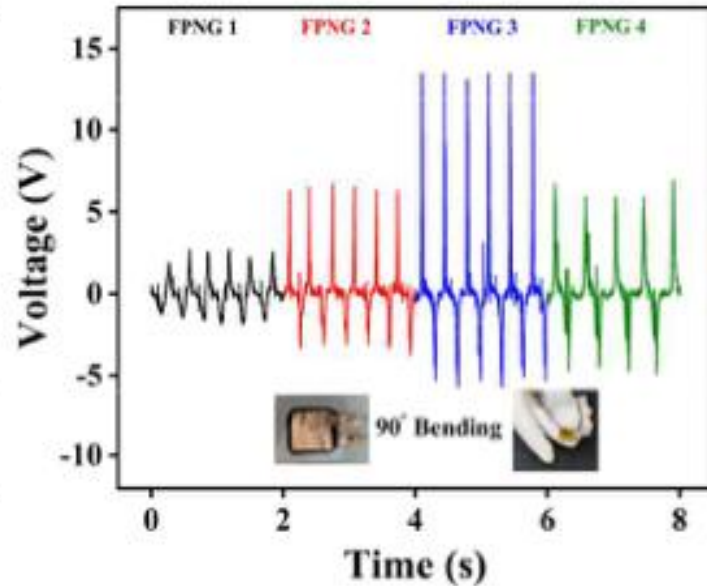
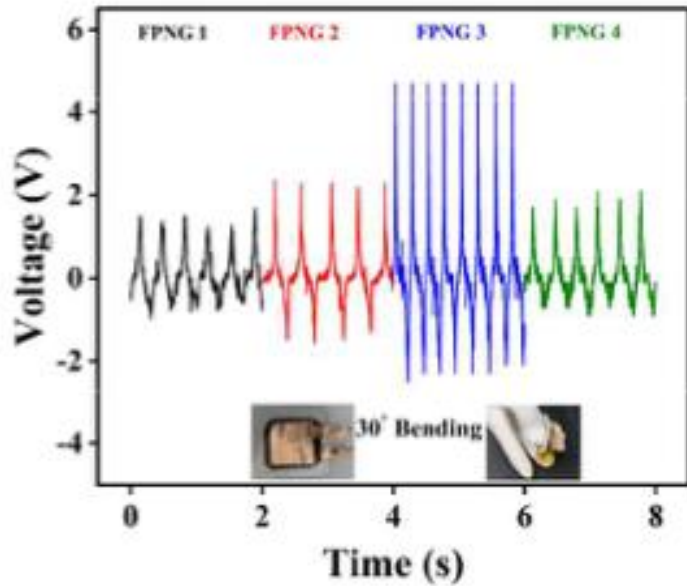
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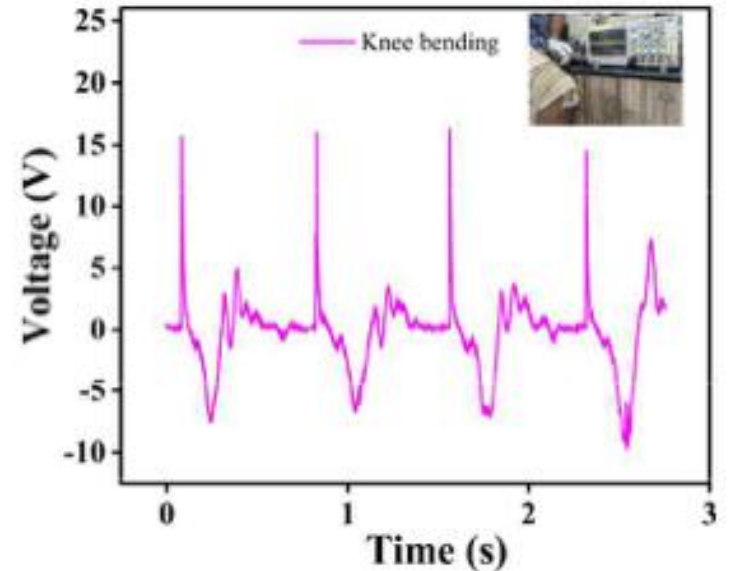
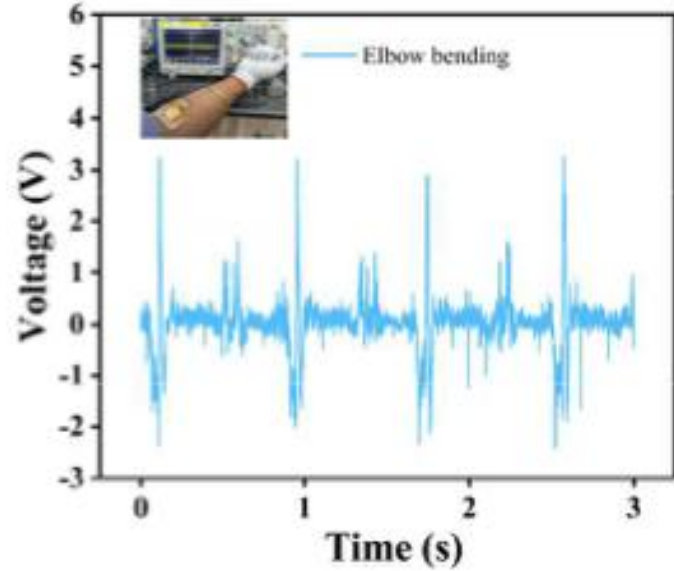
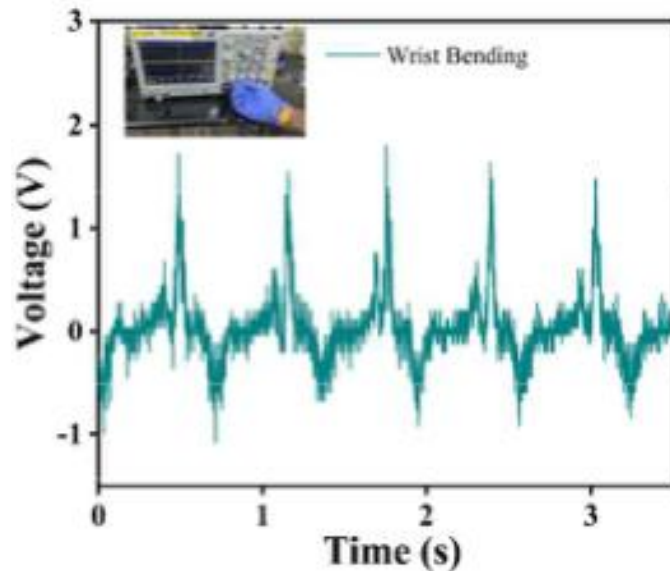
PVDF is found to stabilize the black phase of FAPbI₃ perovskite



Polymer Perovskite Composites For Energy Harvesting



Different body motion results in different output voltages



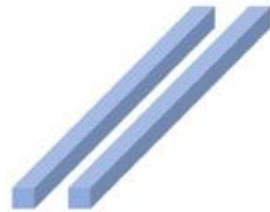
Polymer - Perovskite Composites For Energy Harvesting



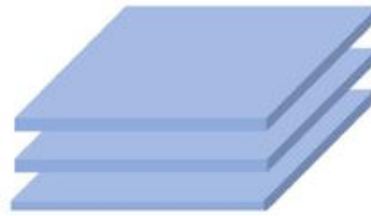
What happens when we have low - dimensional perovskites?



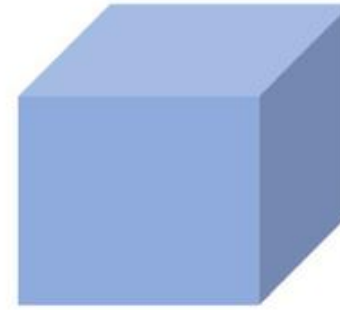
Nanocrystals



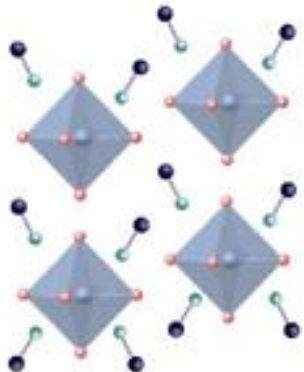
Nanowires
/nanorods



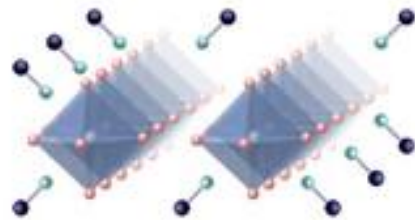
Nanoplatelets
/nanosheets



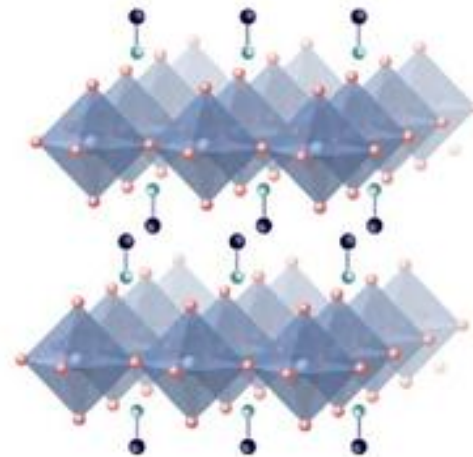
Bulk materials



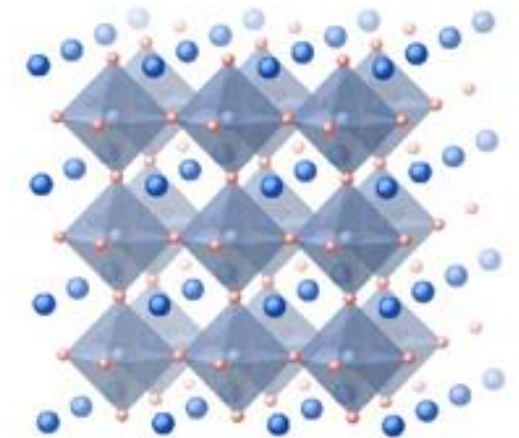
0 D



1 D

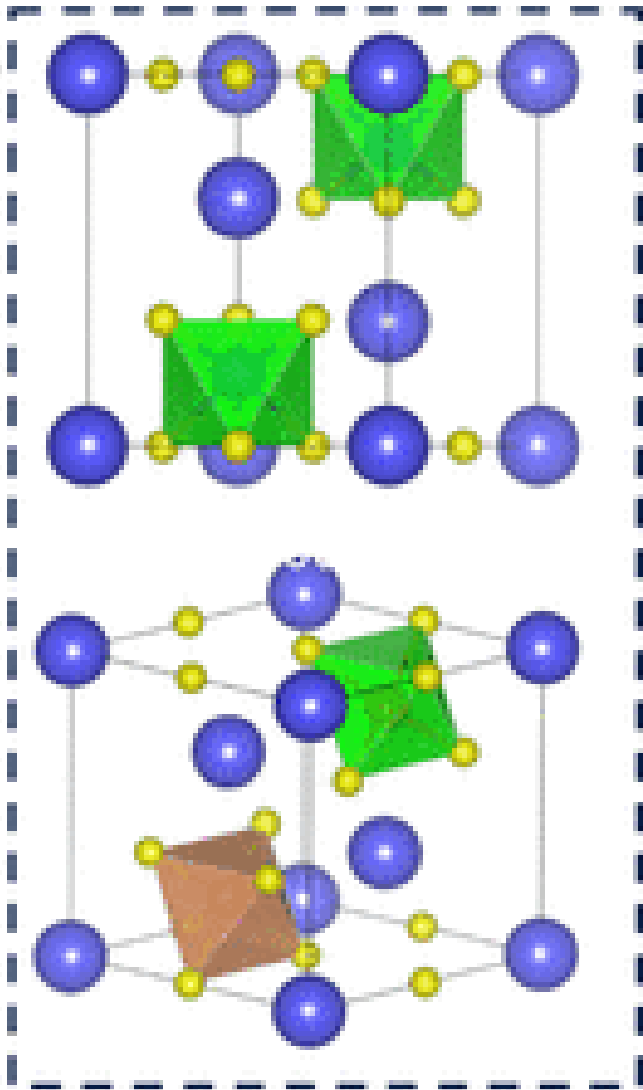


2 D

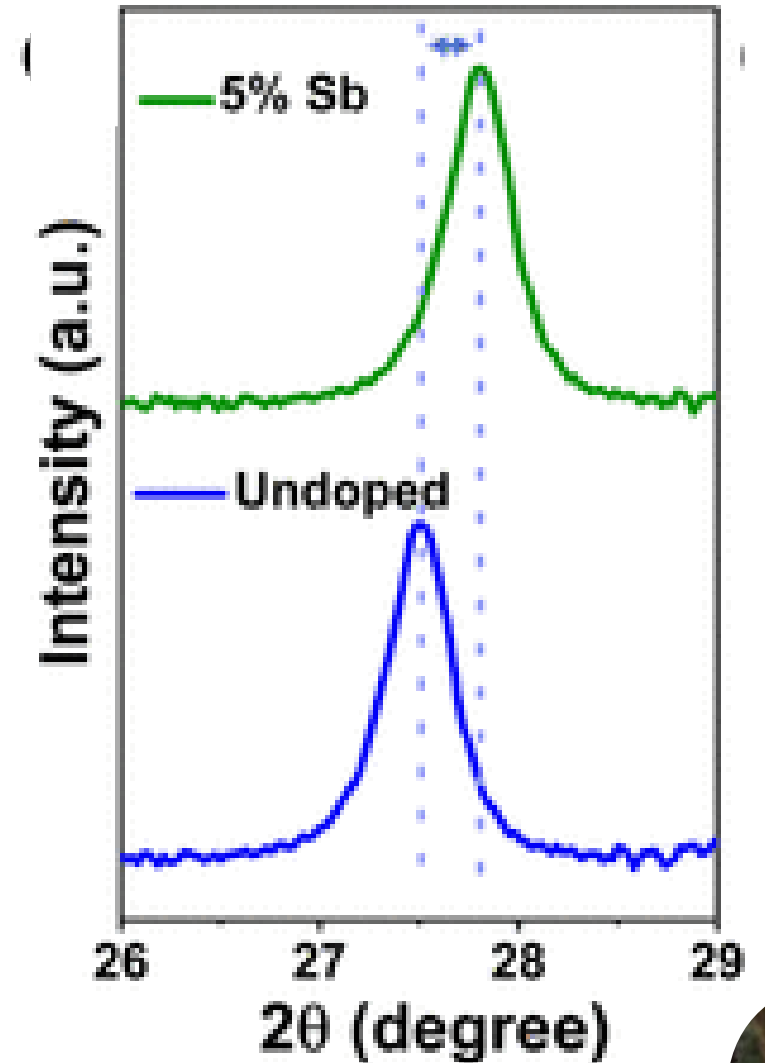
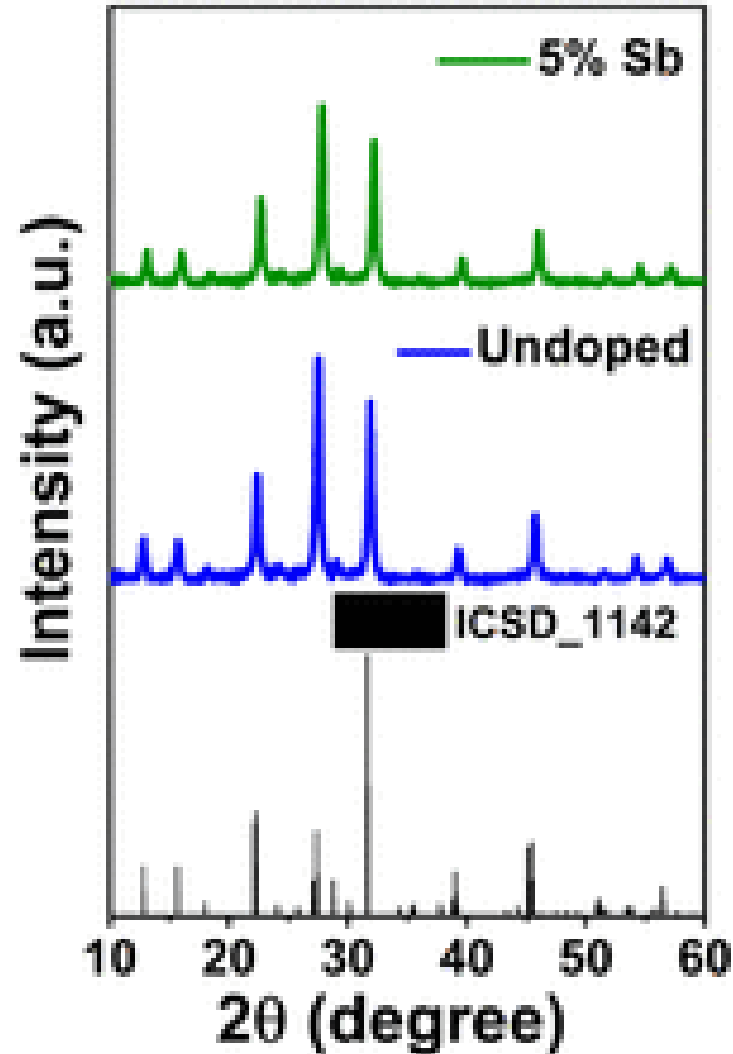


3 D

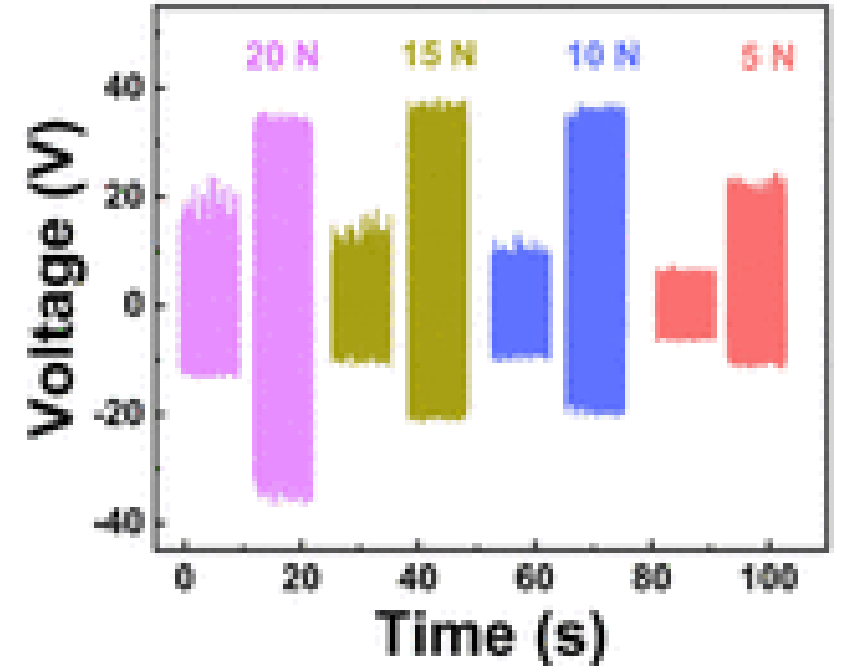
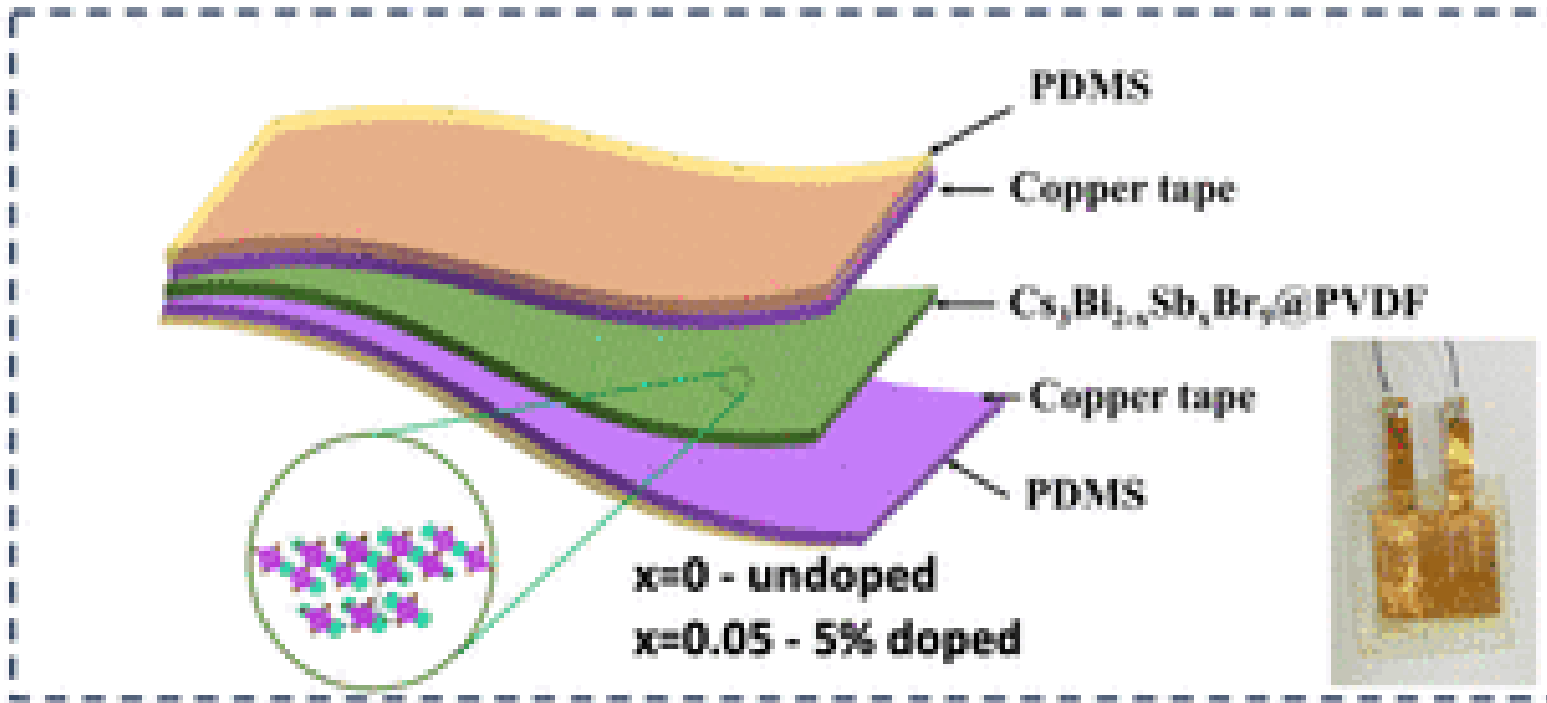
Polymer Perovskite Composites For Energy Harvesting



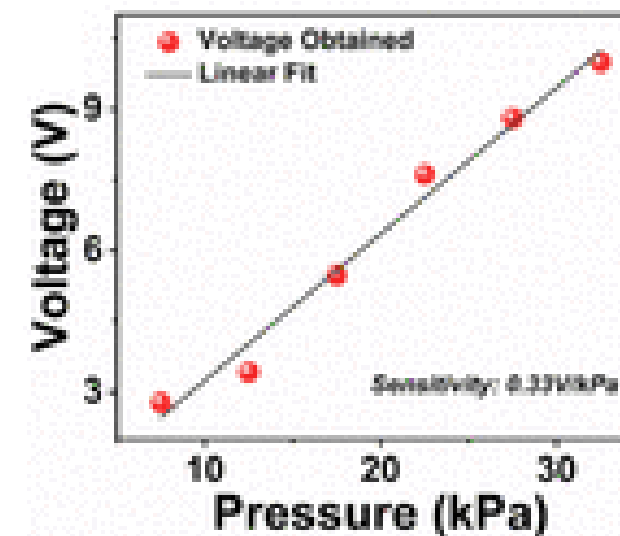
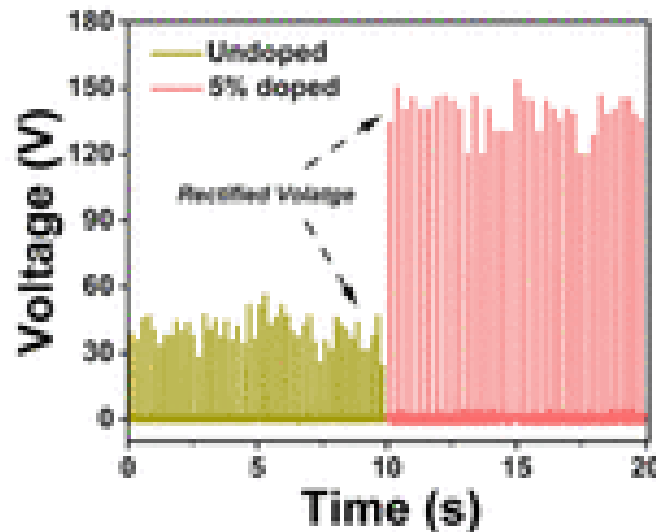
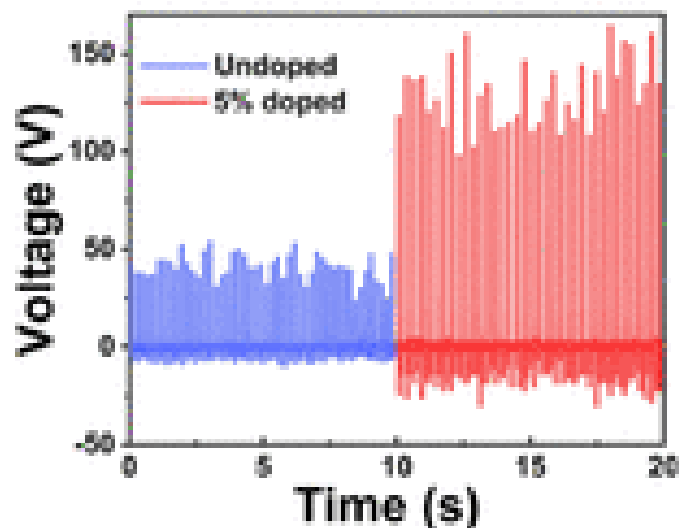
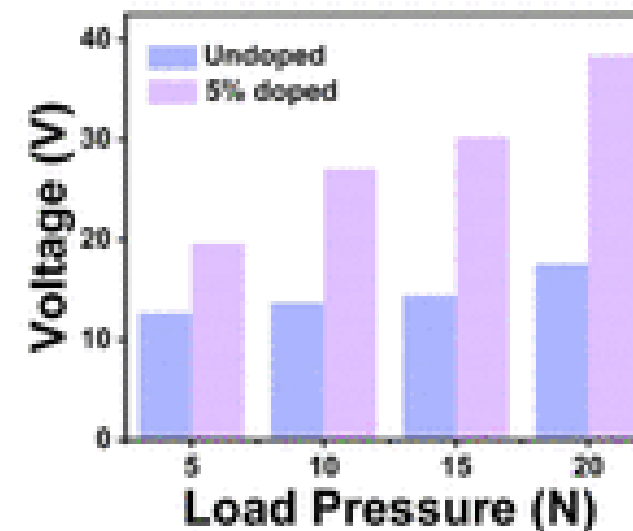
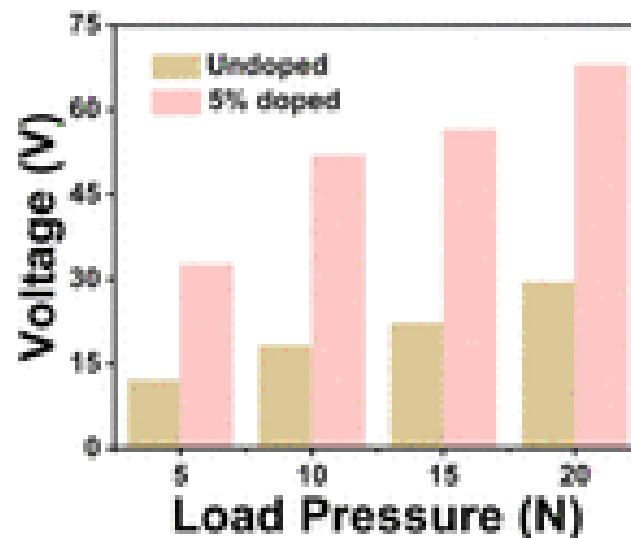
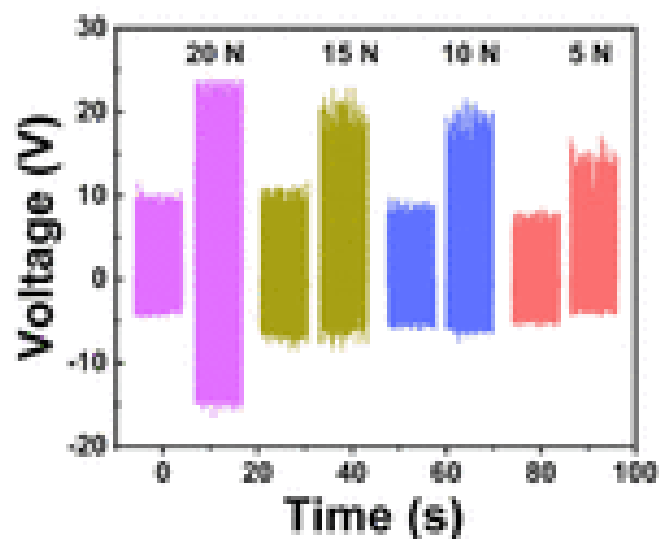
- Cs
- Sb
- BI
- Br



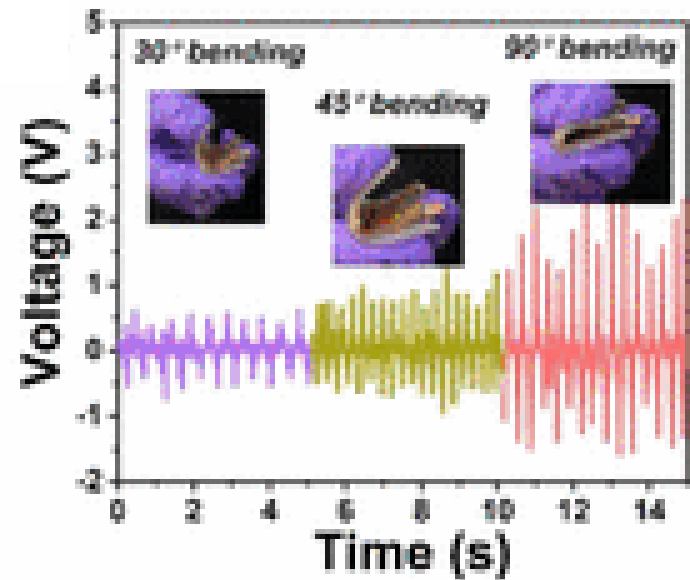
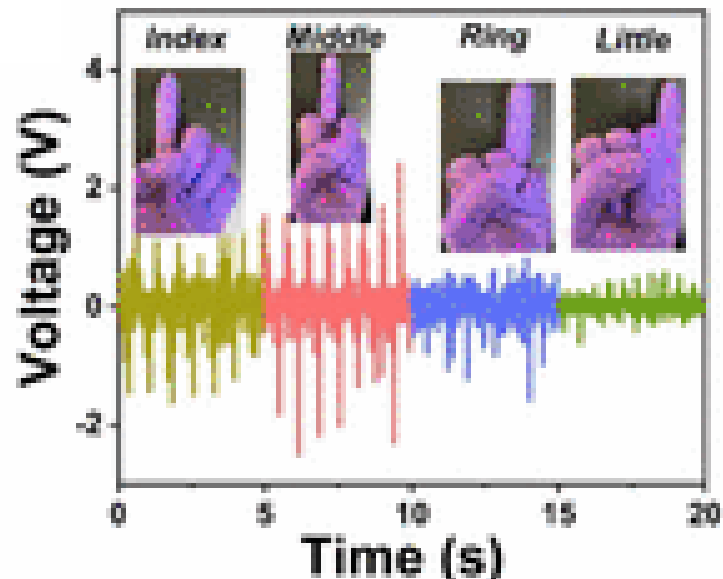
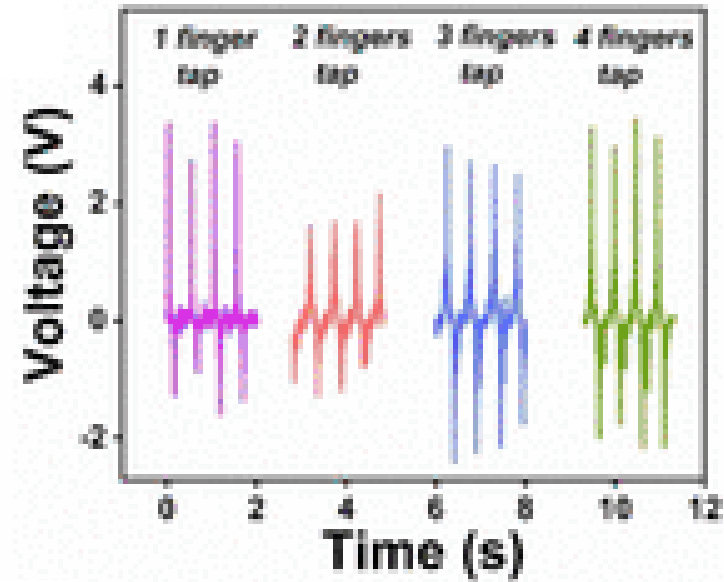
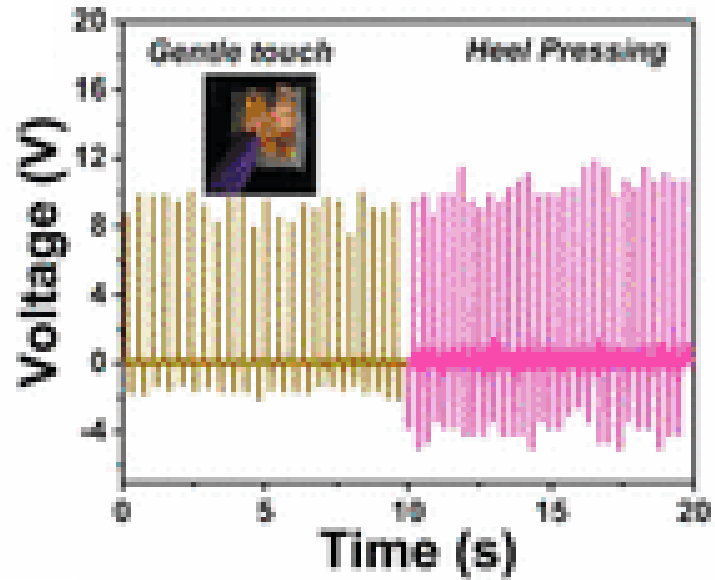
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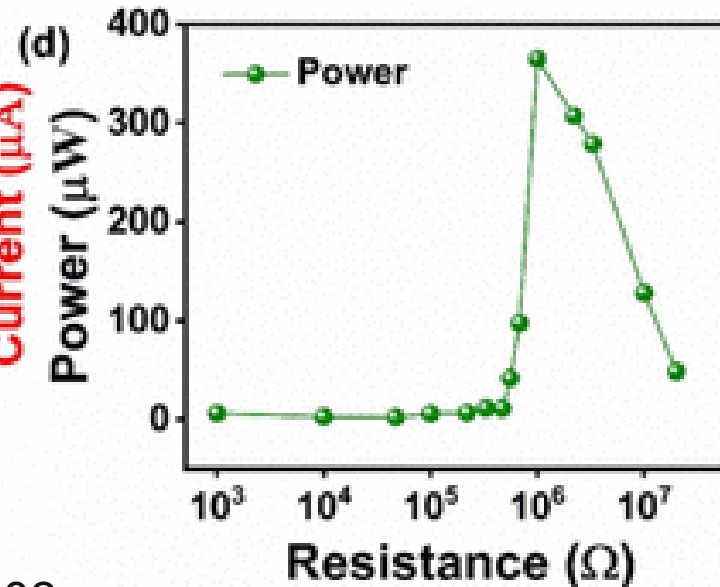
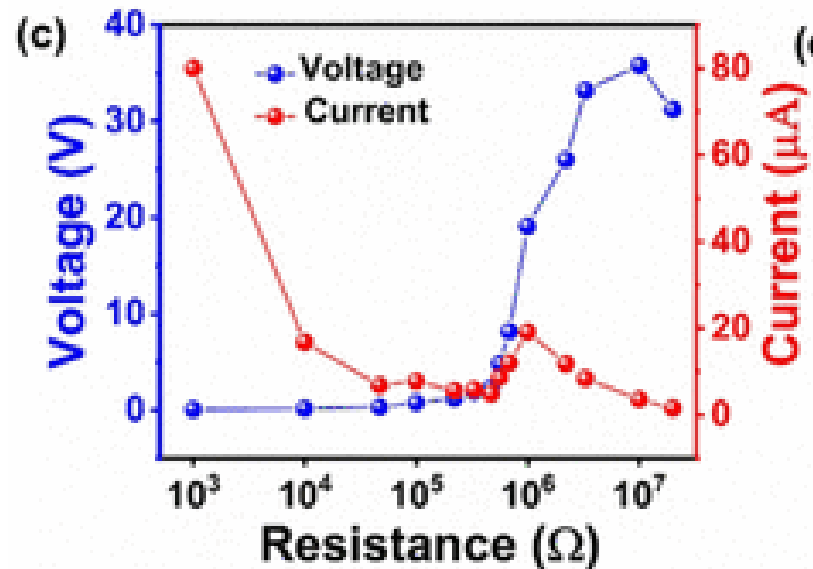
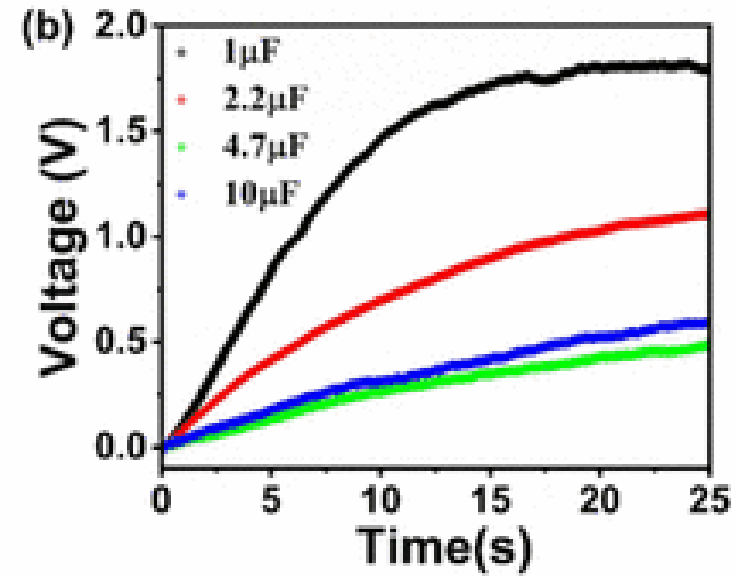
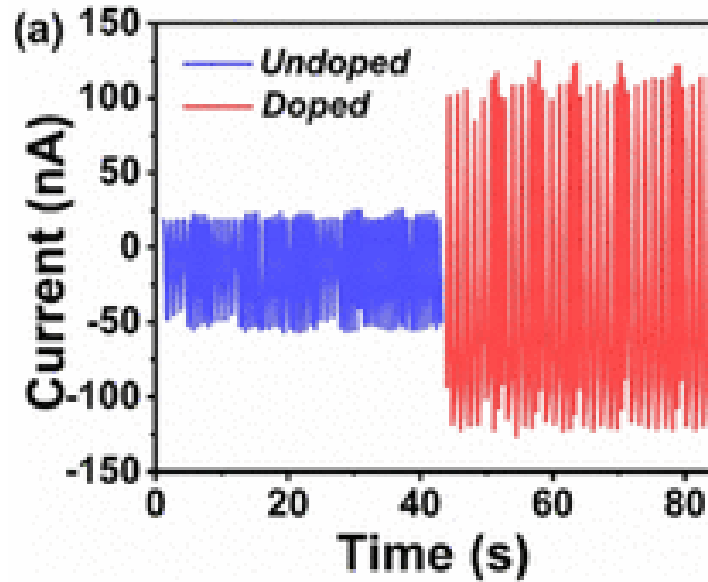
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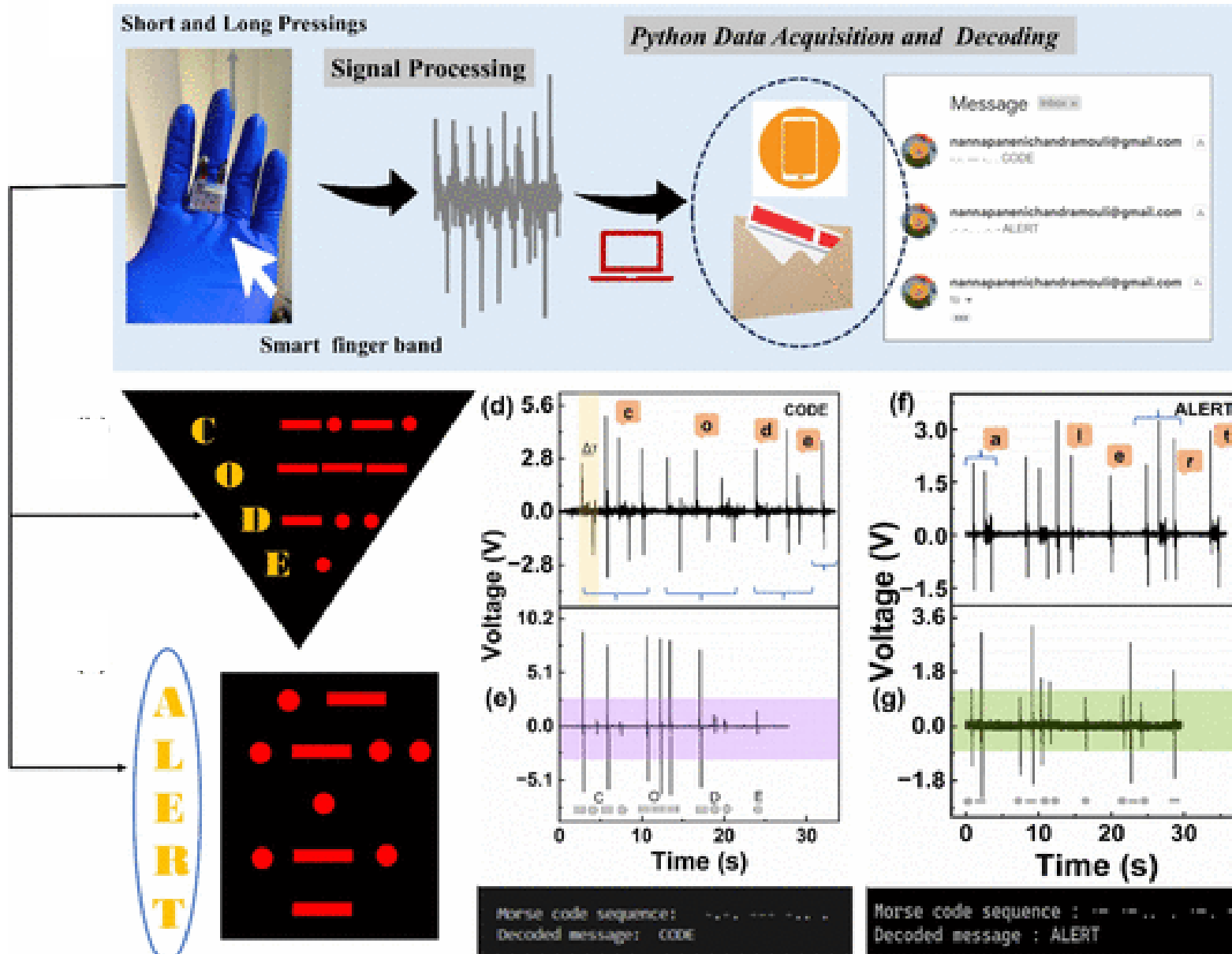
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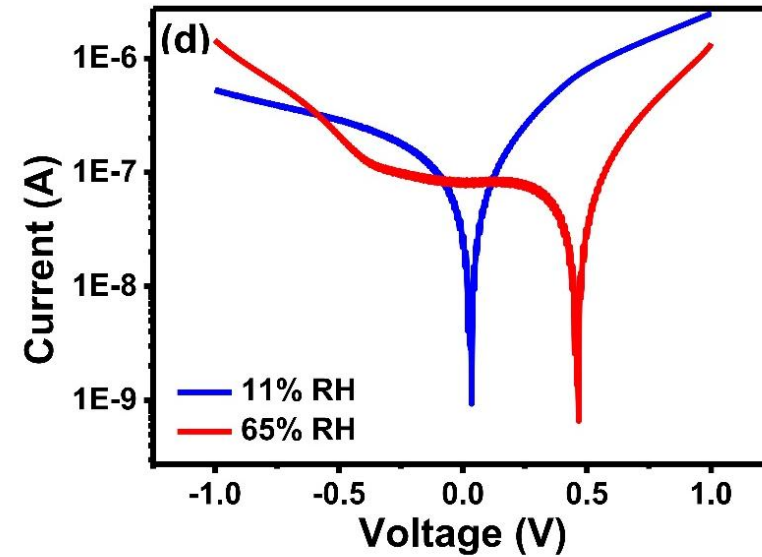
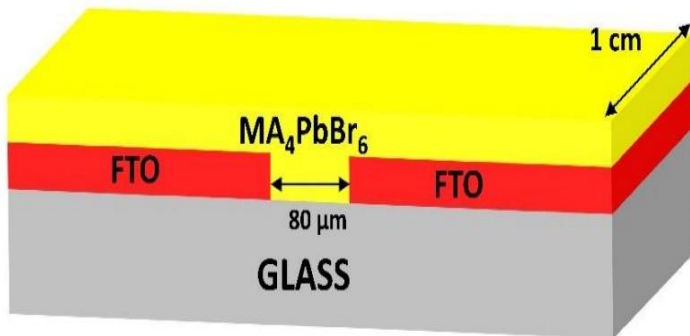
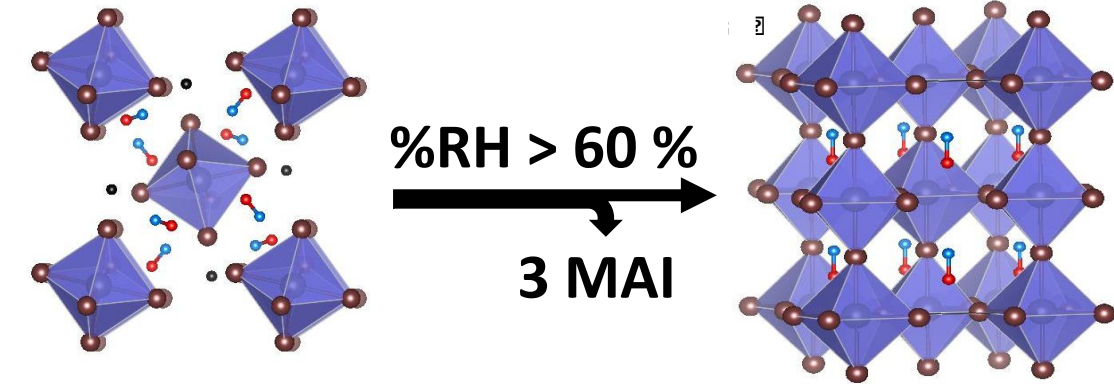
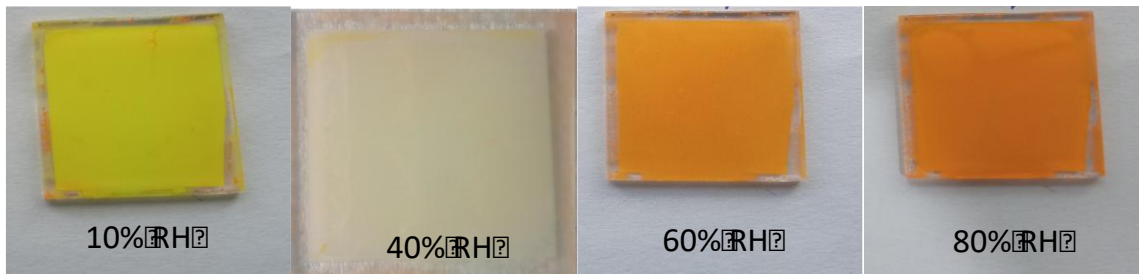


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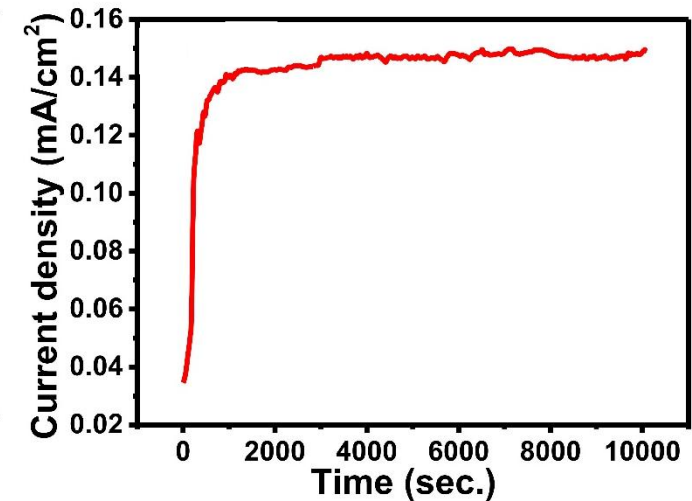
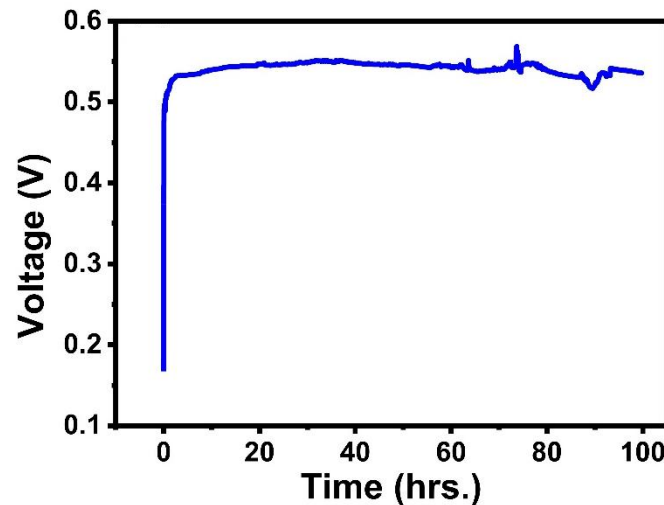


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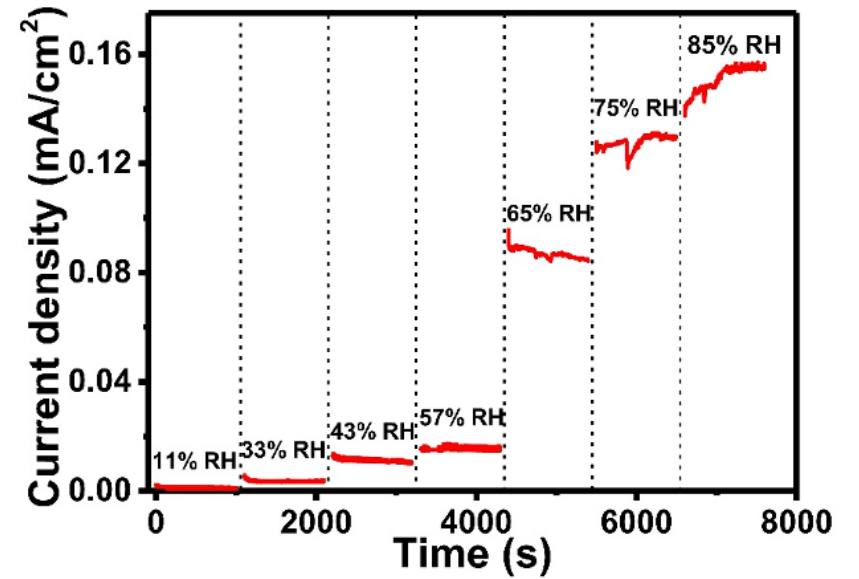
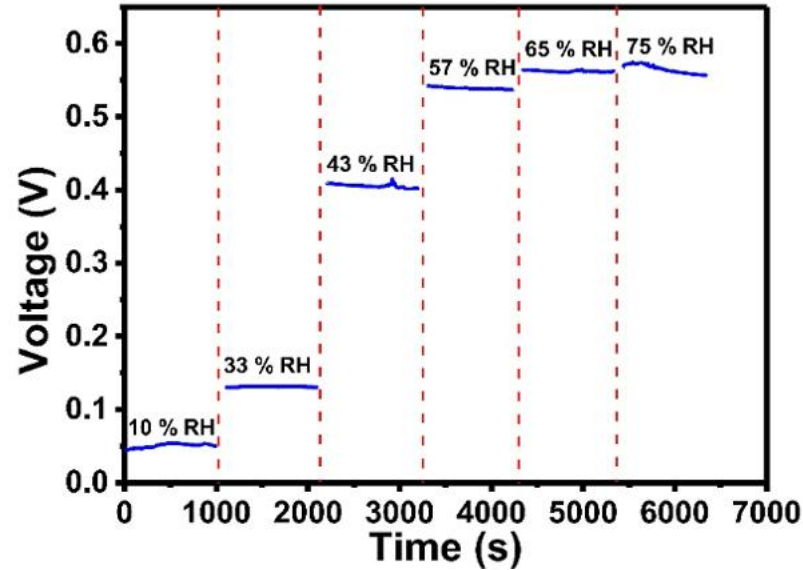
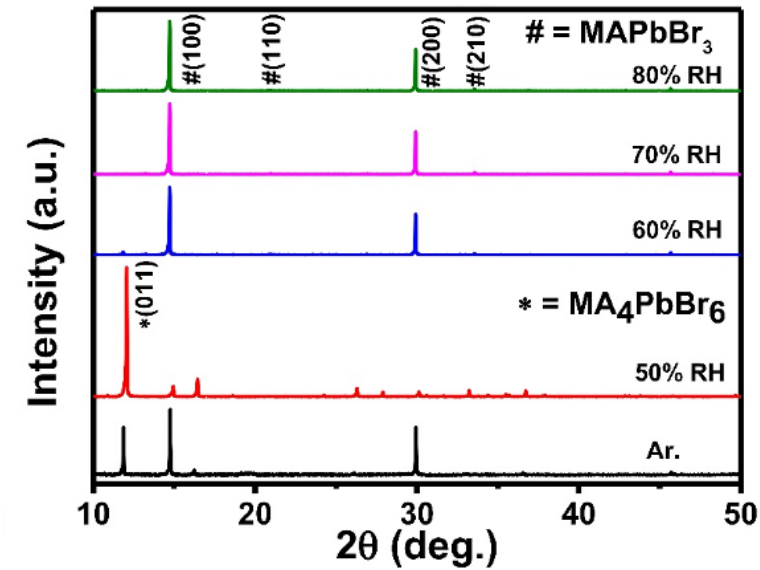
Polymer Perovskite Composites For Energy Harvesting



Voltage is stable for days whereas current drops after a few hours

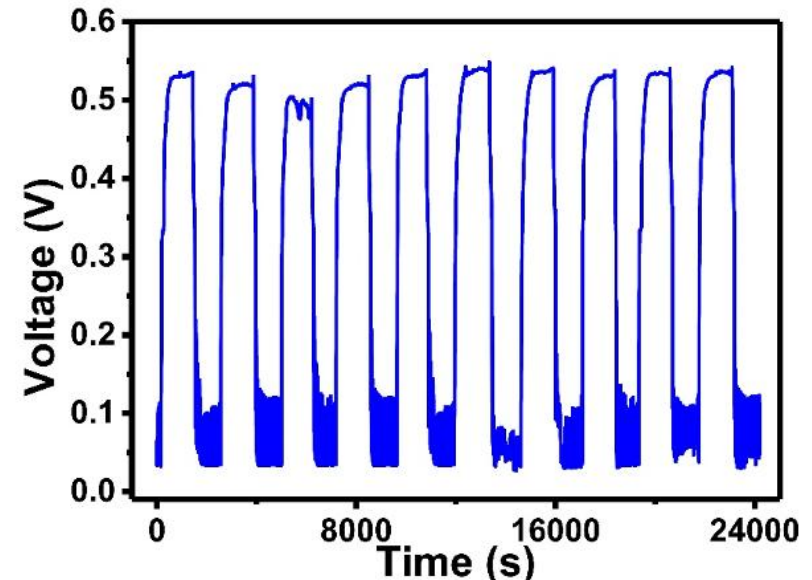


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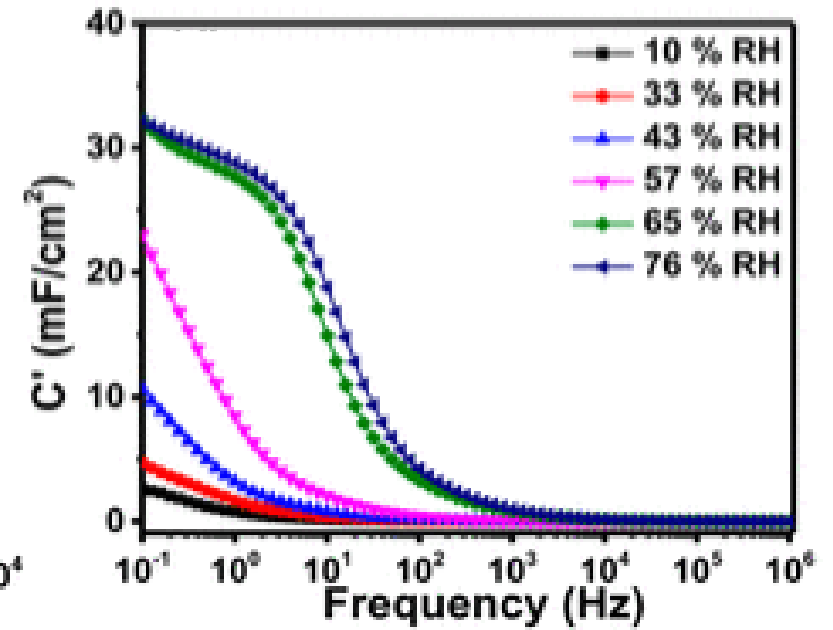
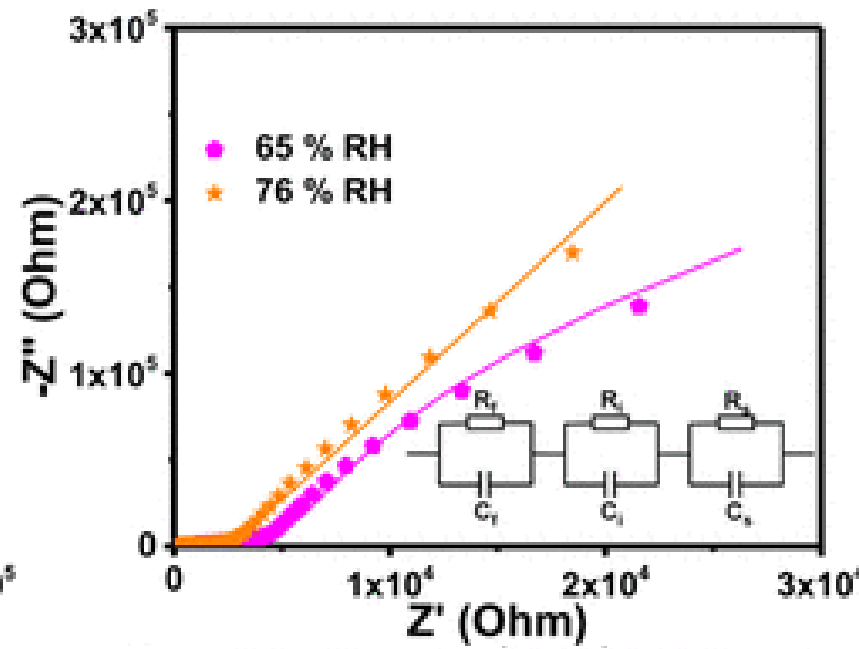
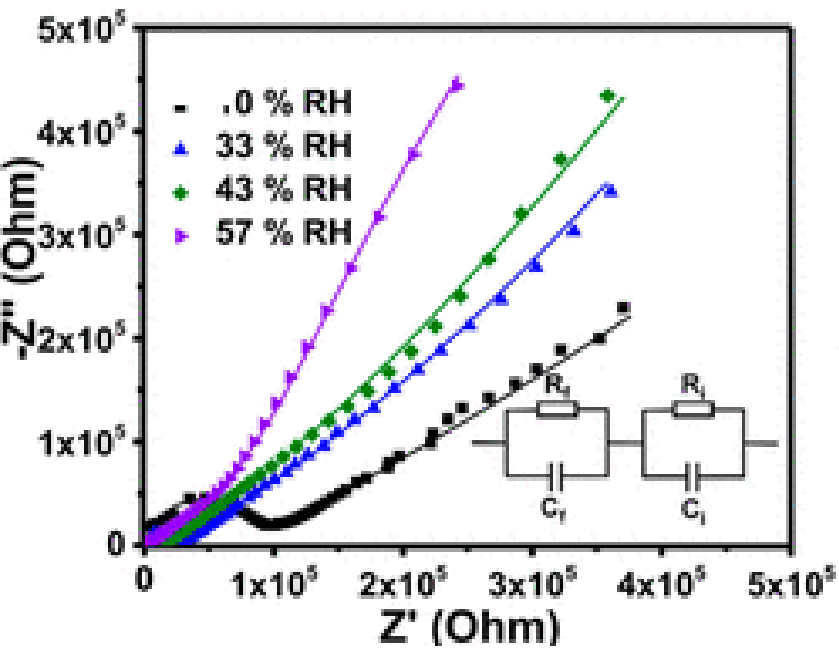


Transformation from 0D to 3D perovskite at humidity >60% RH

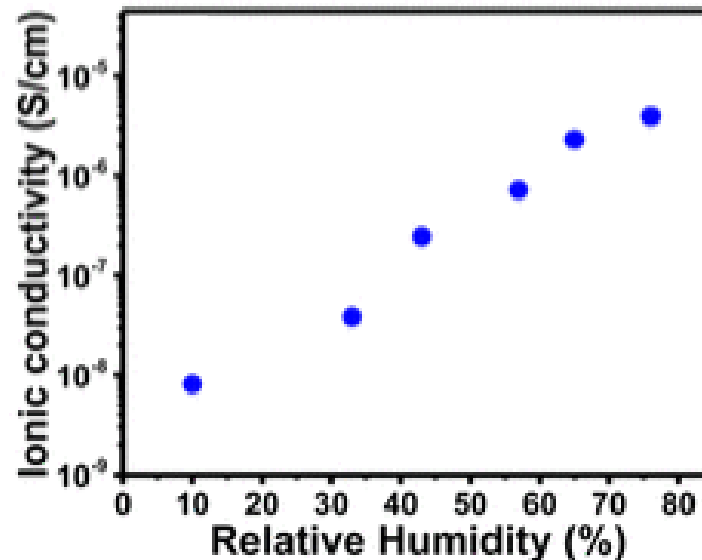
Voltage and current is high after the transformation from 0D to 3D perovskite



Polymer Perovskite Composites For Energy Harvesting



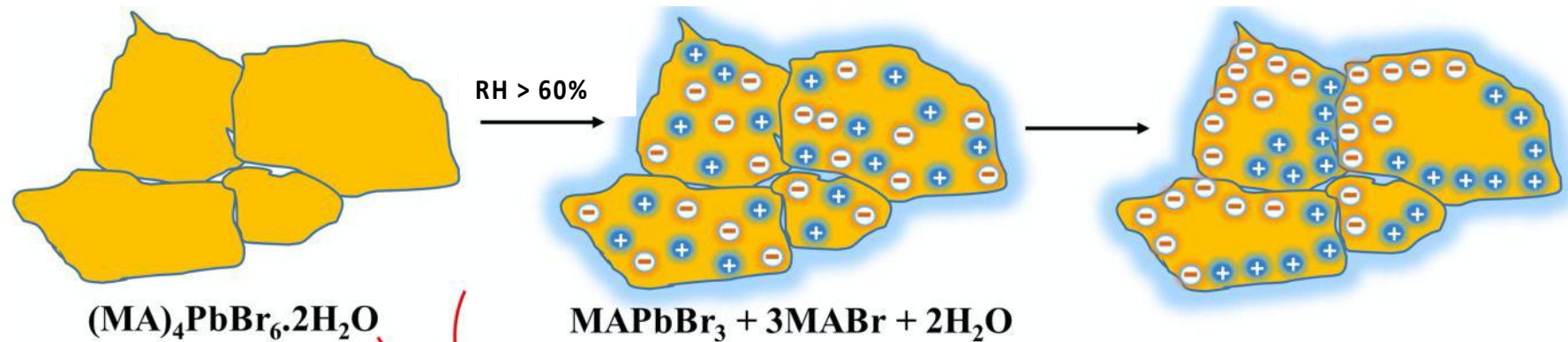
Ionic conductivity increases with humidity



Capacitance increases with the humidity

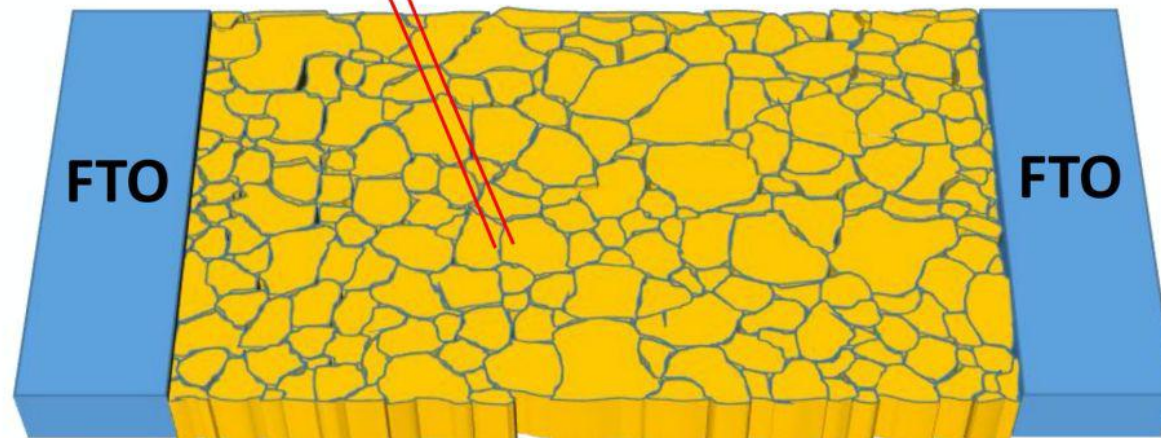


Polymer Perovskite Composites For Energy Harvesting

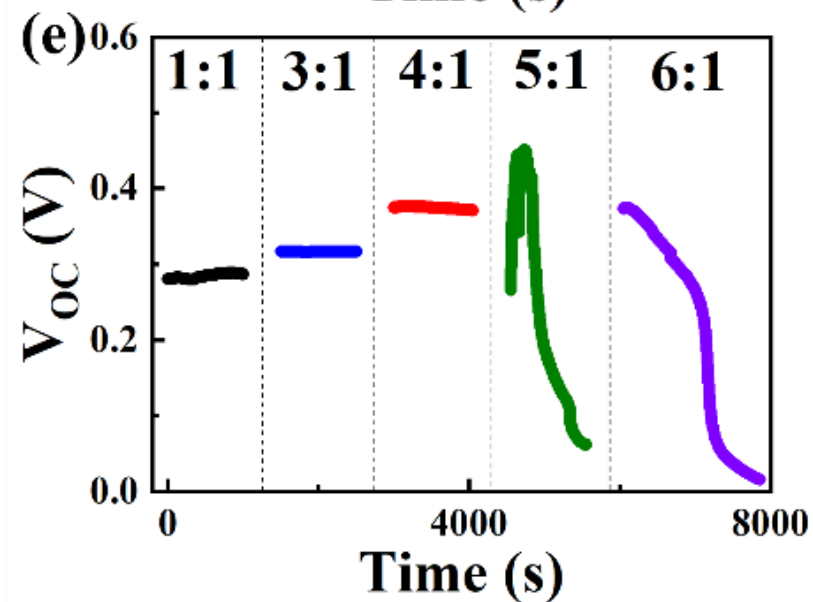
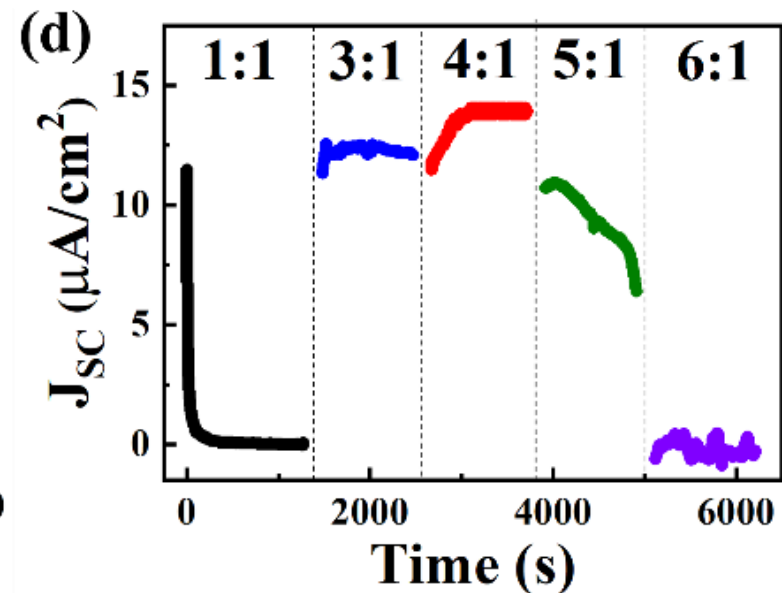
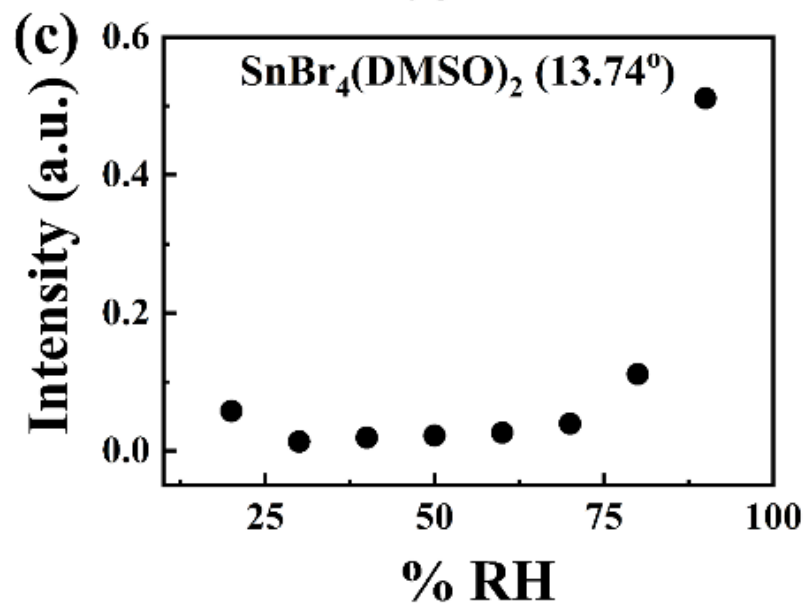
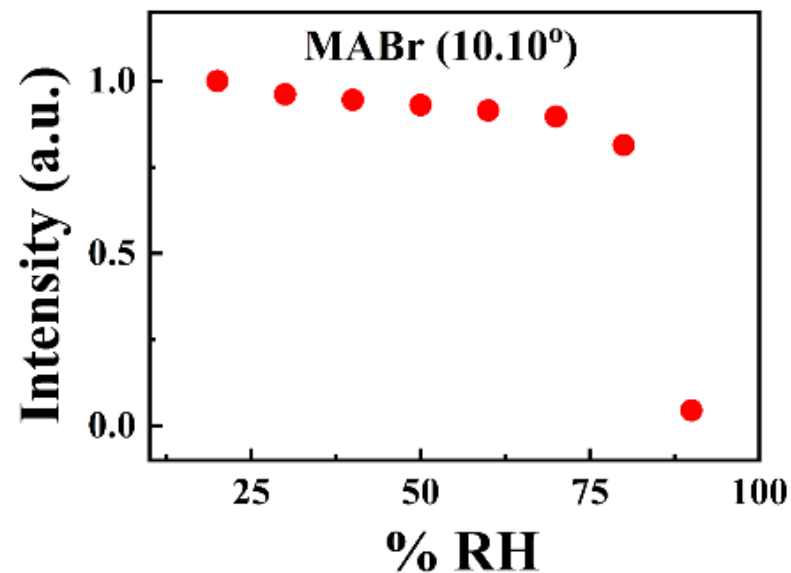
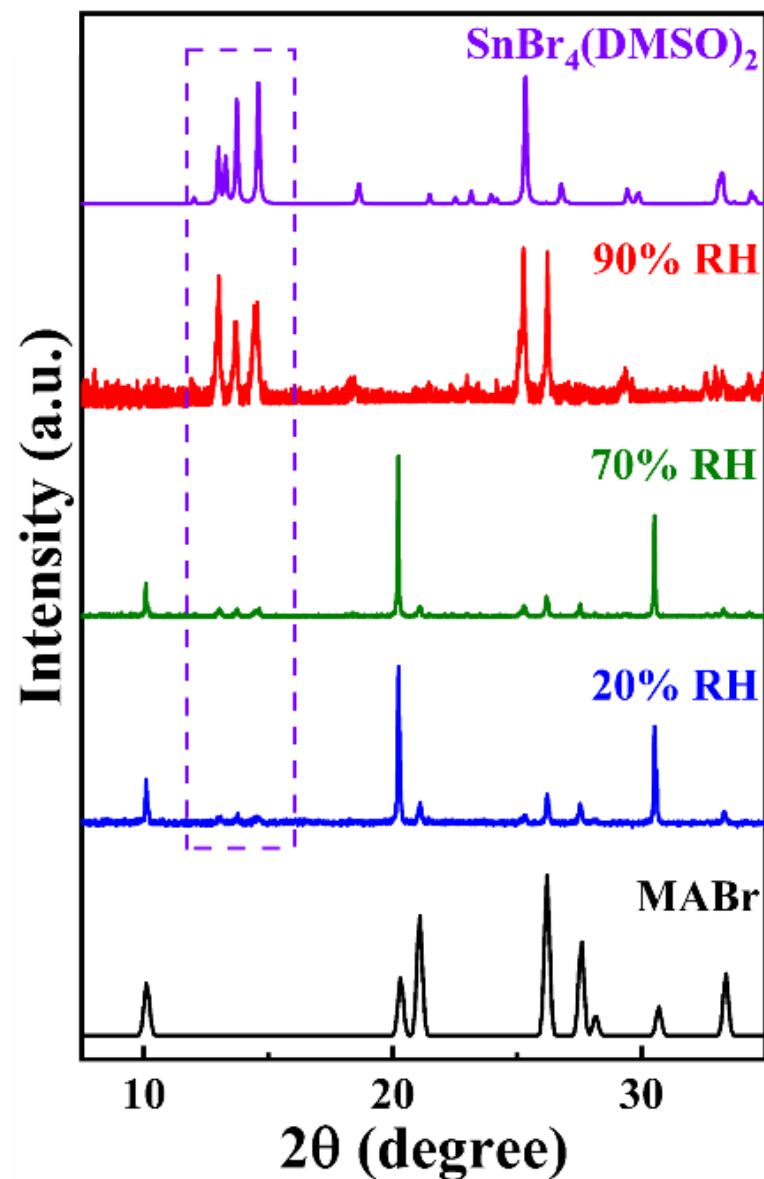


Voltage attributed to the double layer formation

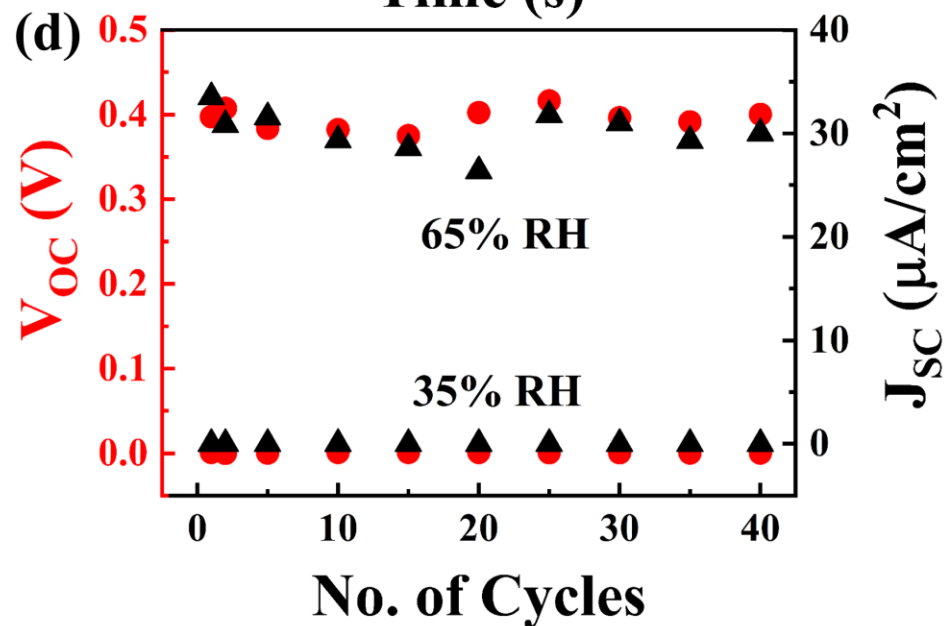
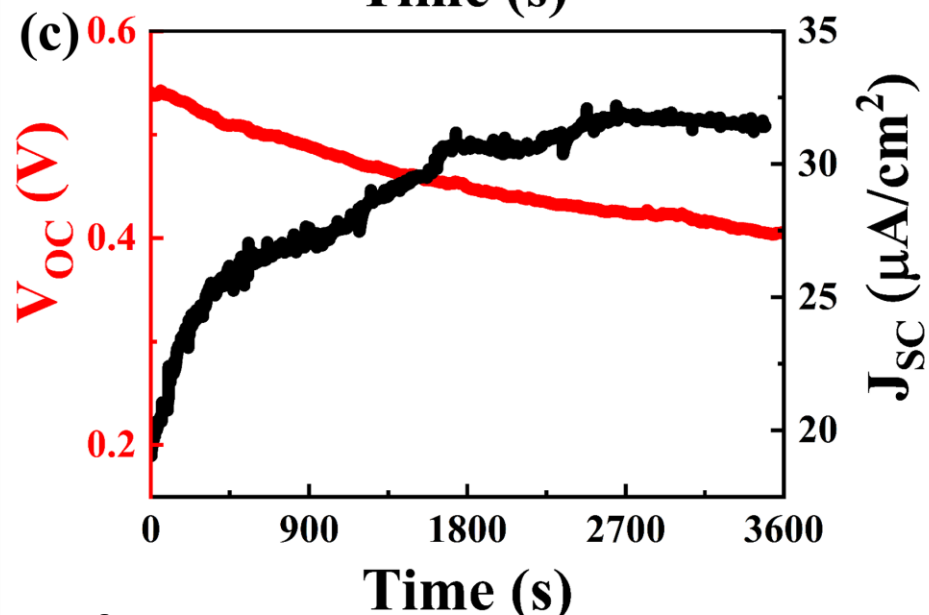
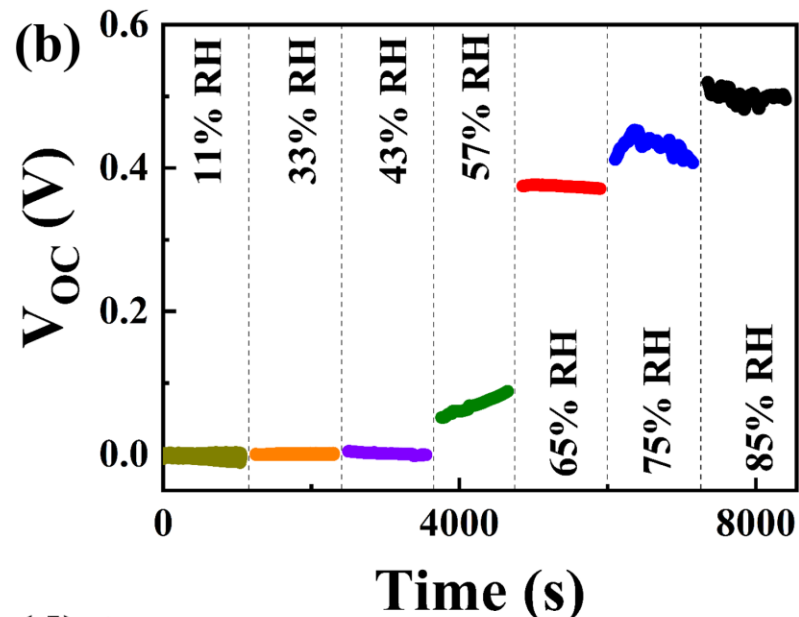
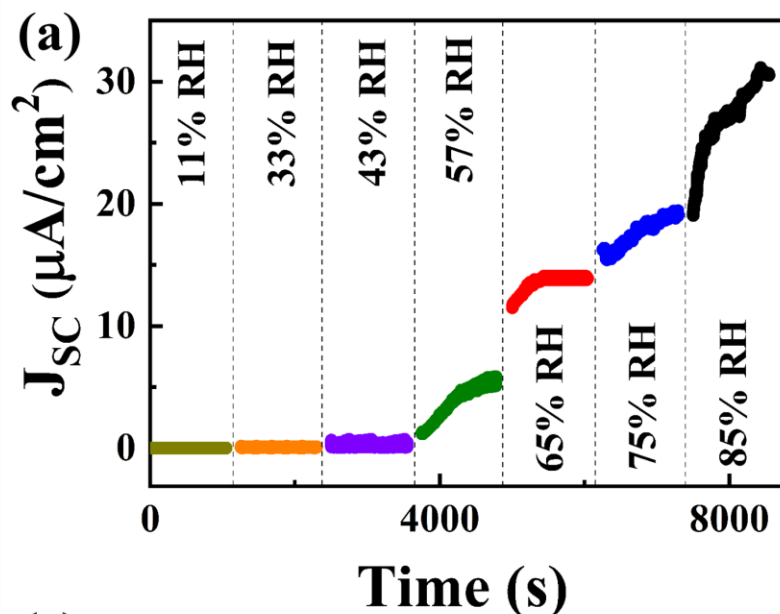
Current attributed to the moment of the ions within the grains



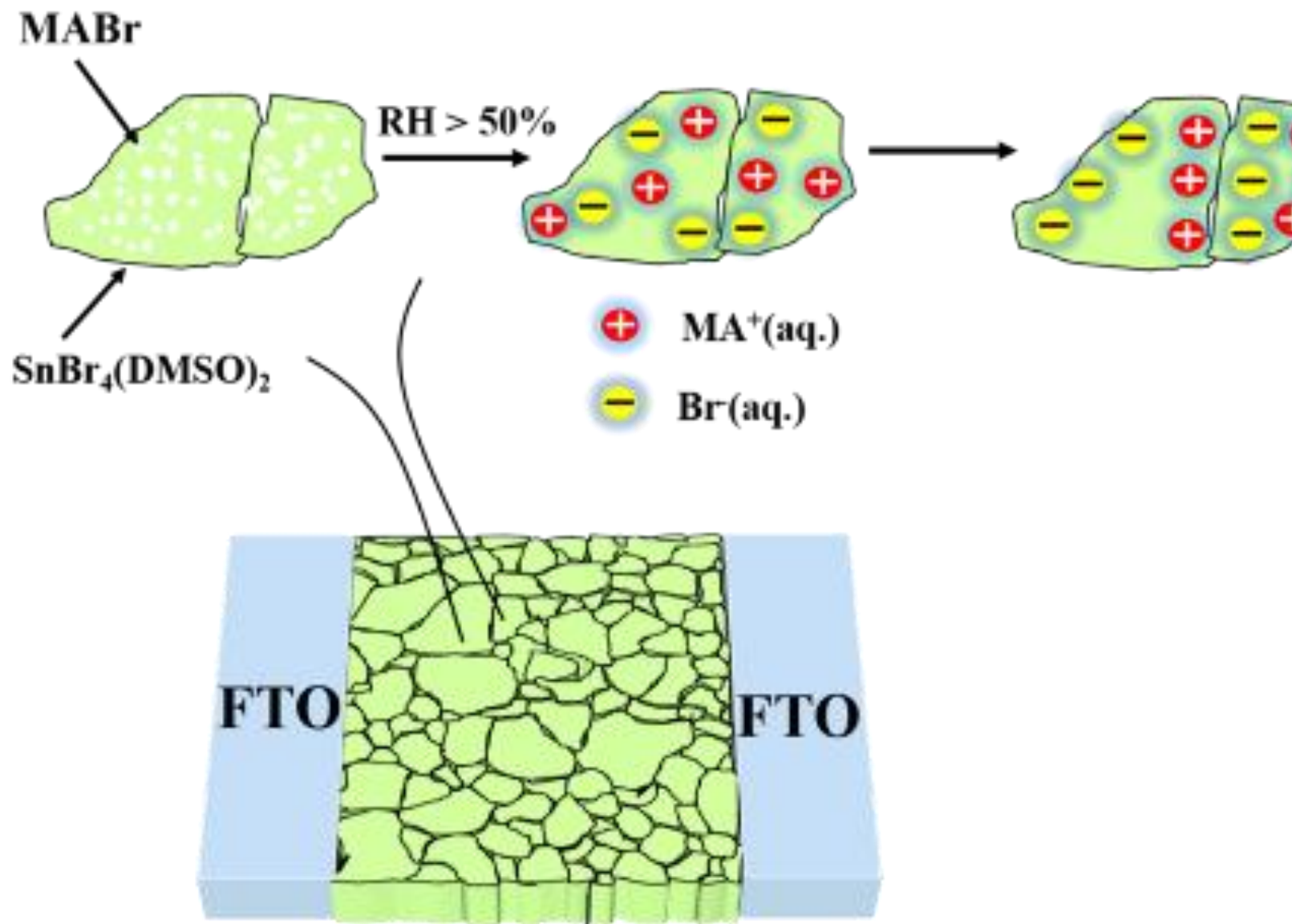
Do we need the phase transformation from 0D-3D?



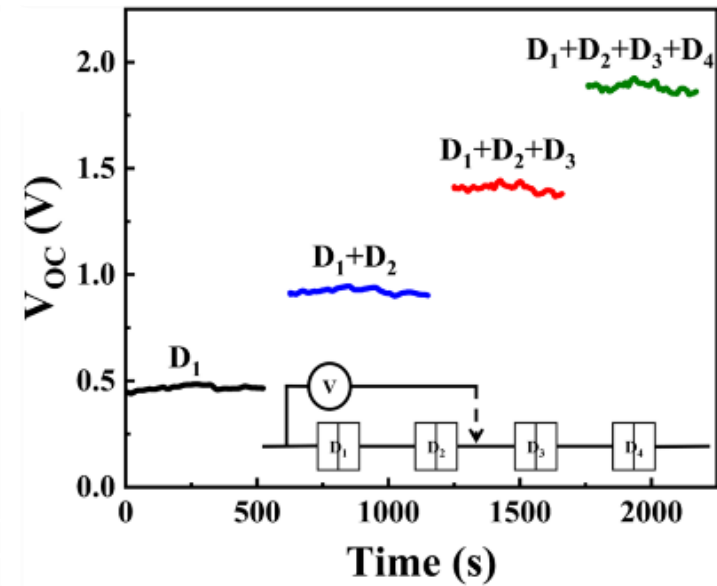
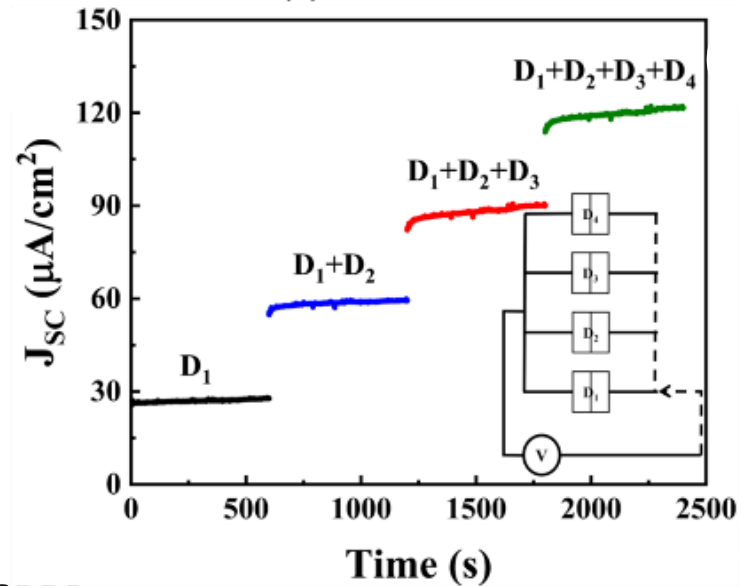
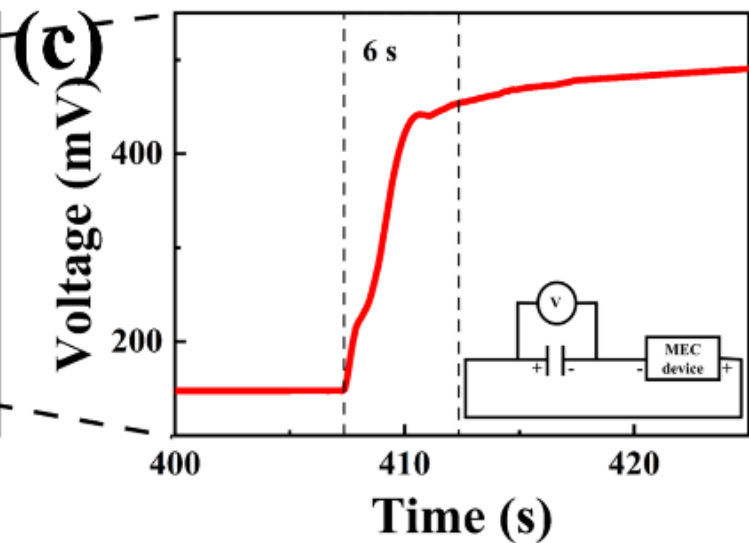
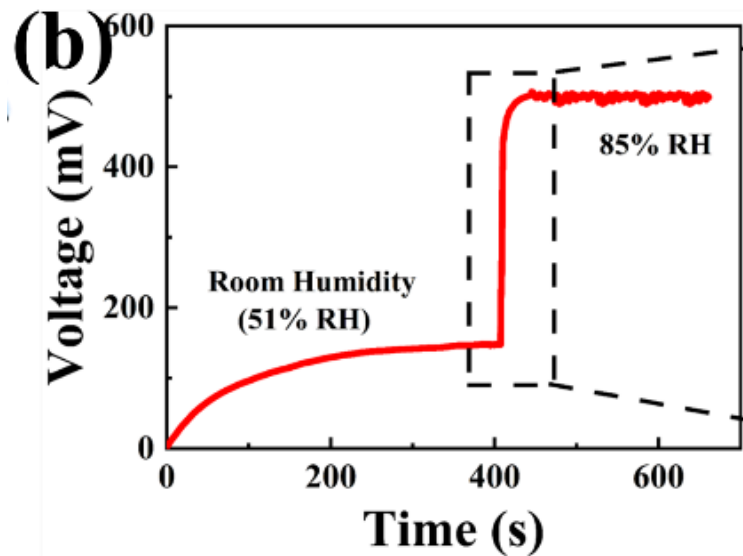
Tin based Perovskite Materials for Humidity Sensing



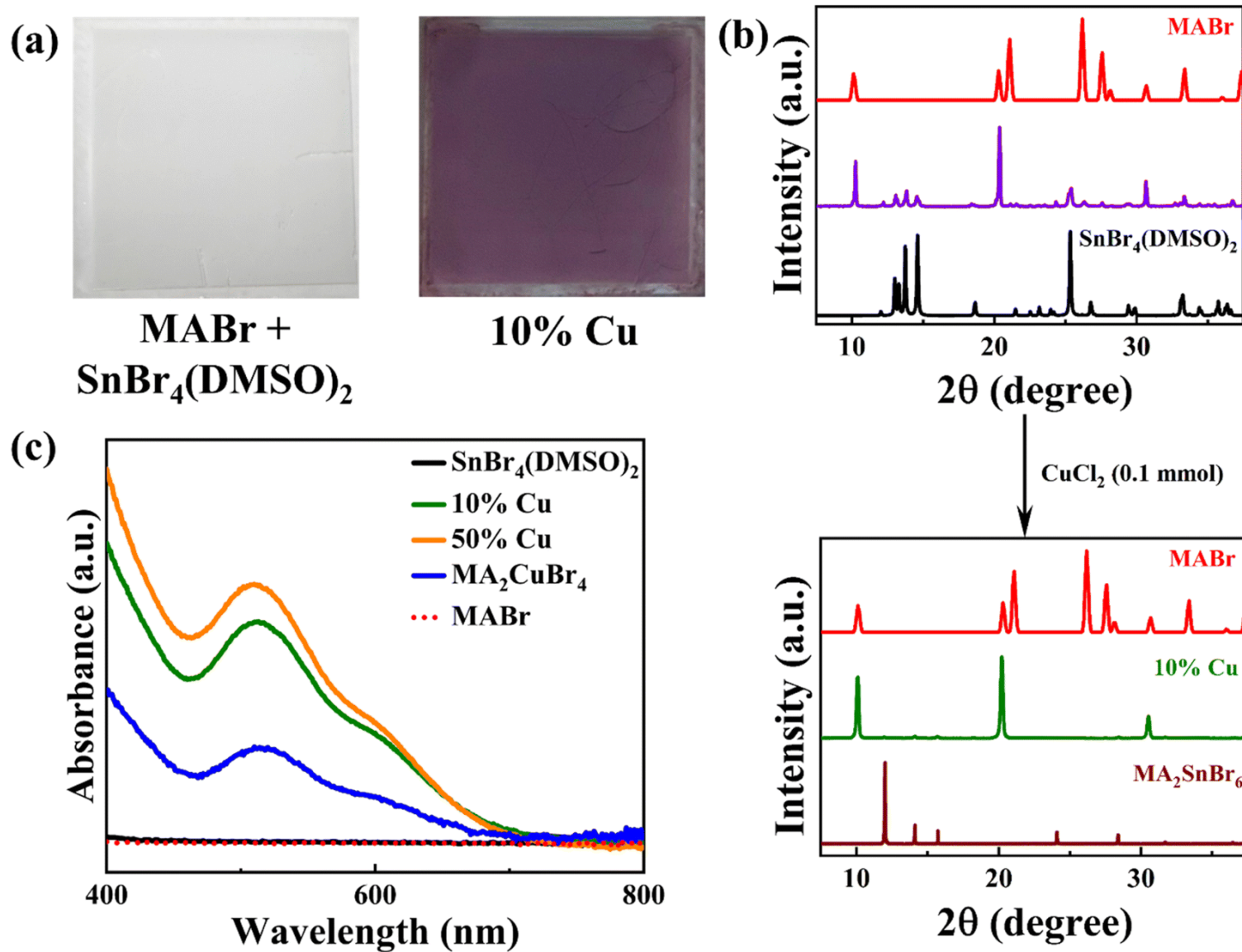
Tin based Perovskite Materials for Humidity Sensing



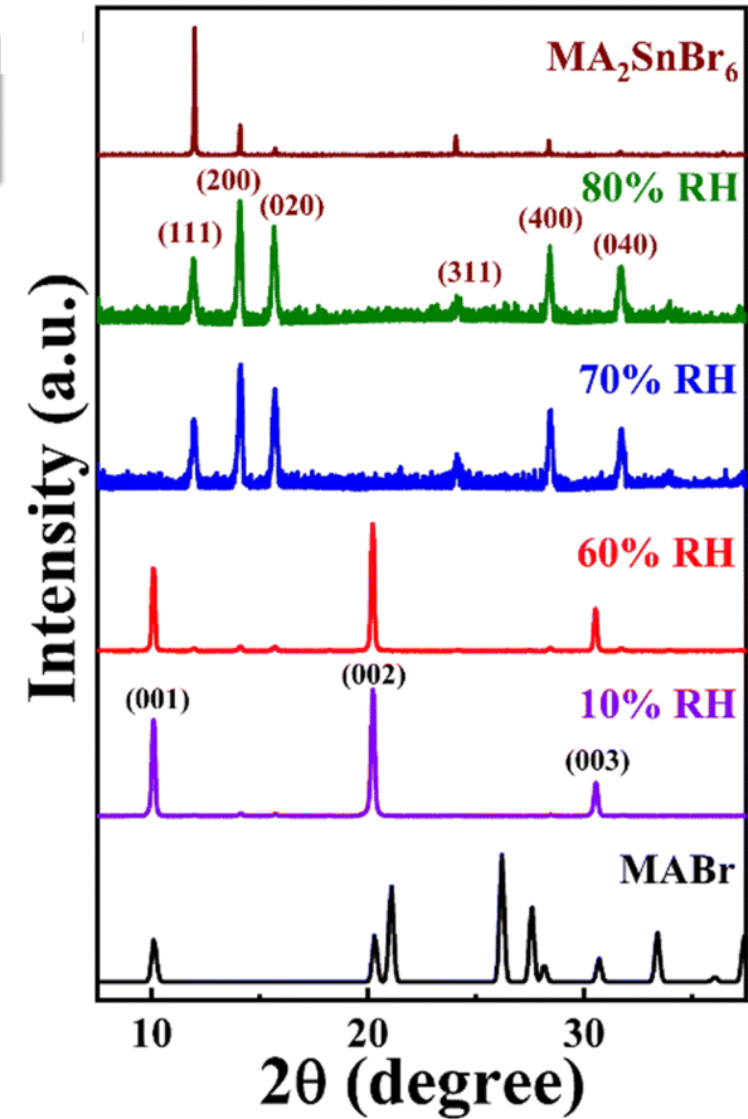
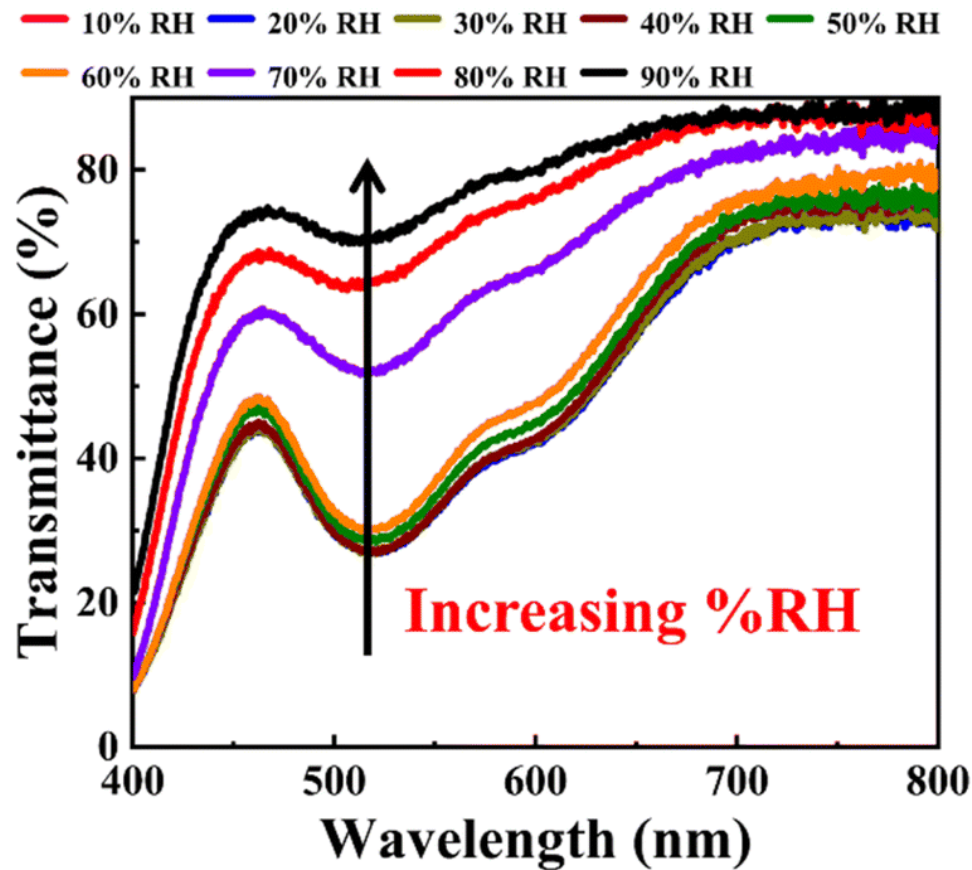
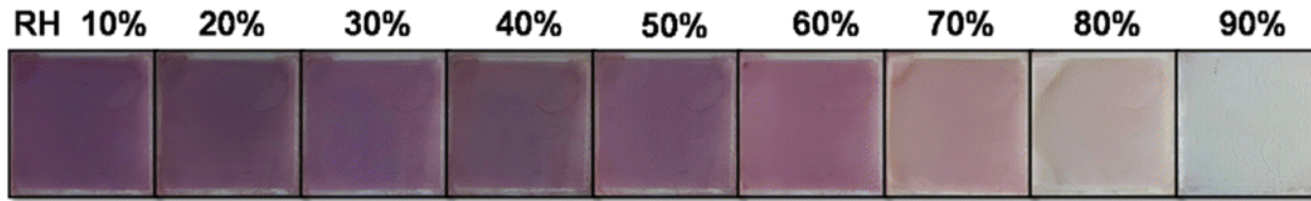
Tin based Perovskite Materials for Humidity Sensing



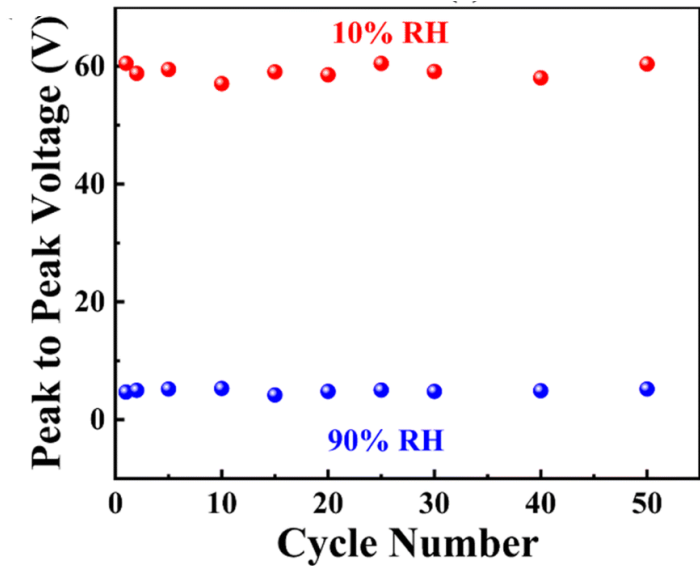
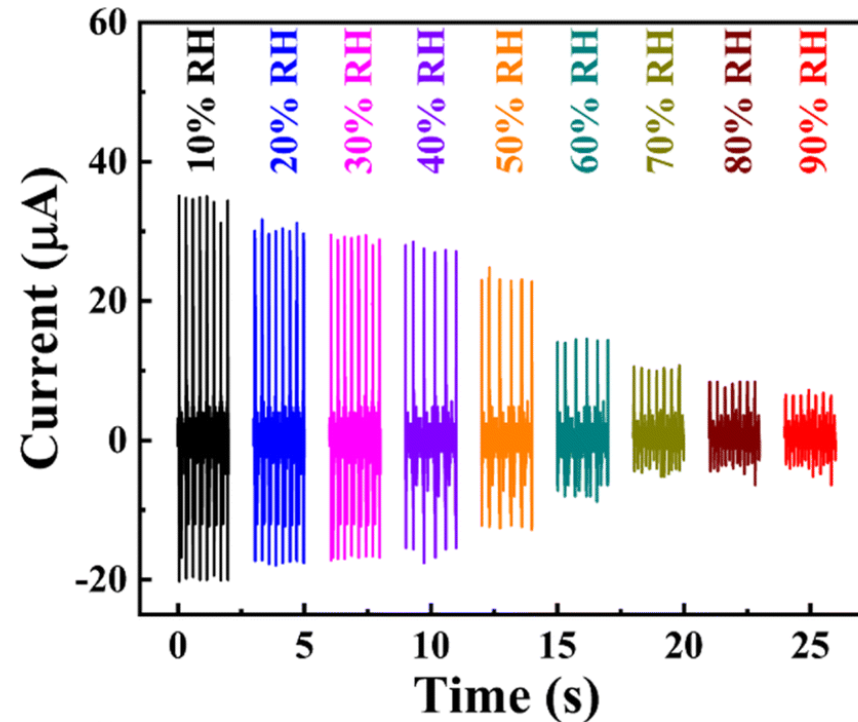
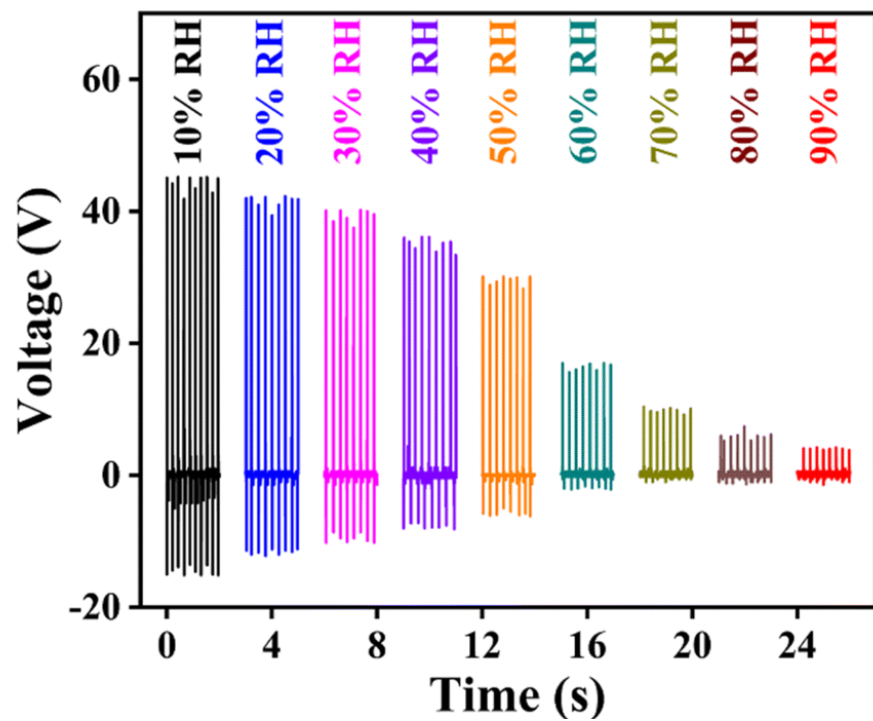
Tin based Perovskite Materials for Humidity Sensing



Polymer Perovskite Composites For Energy Harvesting

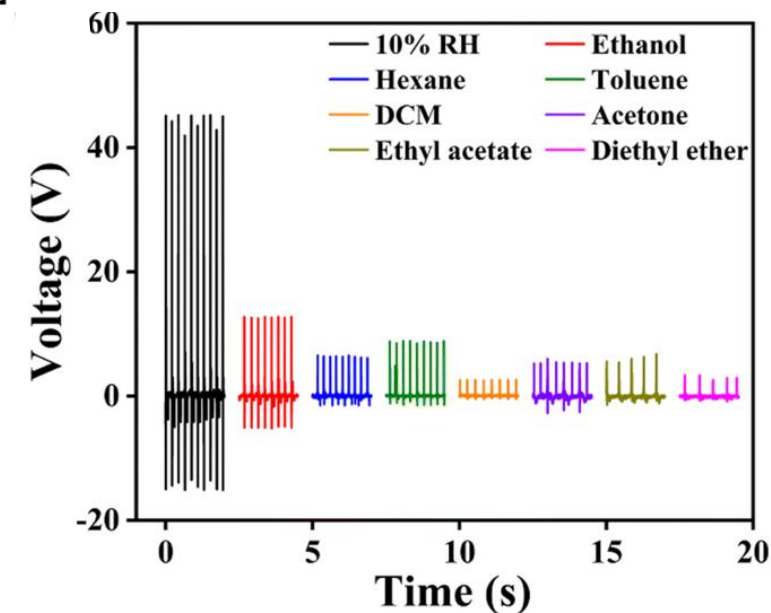


Polymer Perovskite Composites For Energy Harvesting



WVTR of PVDF is $95 \text{ g/m}^2/\text{day}$ at 40°C and 90% RH

Self powered humidity sensing with peak to peak voltage difference of $\sim 60 \text{ mV}$ between 10% RH and 90% RH



Conclusions



- Dielectric confinement results in stable perovskite composite films
- Humidity resistant devices can be made using this approach
- Ambient energy harvesting for self powered sensors

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Thank You