

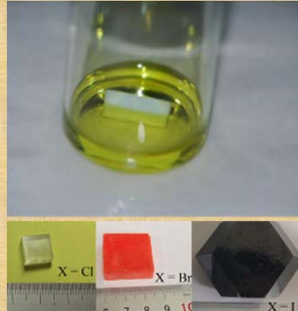
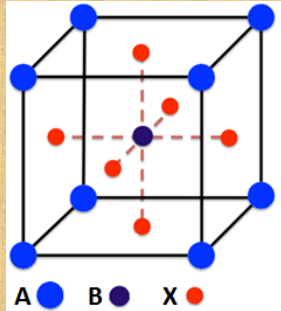


Fully Printed Light-Emitting Diodes Using Halide Perovskite Composite Thin Films

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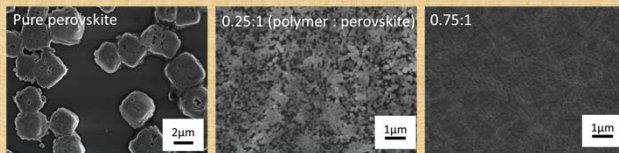
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Halide Perovskites (ABX_3)

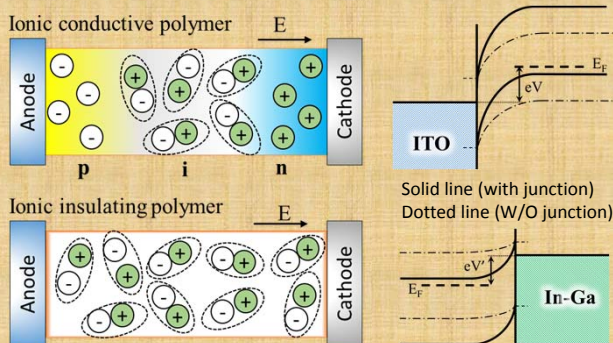


- A ions: Methylammonium (MA^+), Cs^+
- B ions: Pb^{2+} , Sn^{2+}
- X ions: Cl^- , Br^- , I^-
- Tunable bandgaps (UV to near IR)
- Solution processing

Perovskite/Polymer Composite



- Polymer addition can enhance film continuity



- The use of ionic conductive polymer promotes ionic migration in the composite.
- A $p-i-n$ junction is developed *in-situ* that can be used for efficient electron/hole injection in LEDs.

Perovskite LEDs

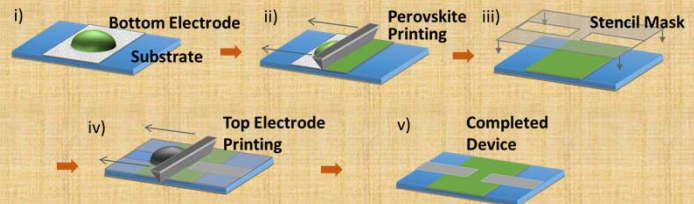
5nm p^+-GaN	Al (100nm)	Top Electrode
95nm $p-GaN$	LiF (0.5nm)	Perovskites (100nm to 3 μm)
20nm $p-Al_{0.95}Ga_{0.05}N$	B3PYMPM (50nm)	ITO
2nm GaN barrier	CBP:ir(ppy) ₃ 8wt% (10nm)	Glass or Plastic
1nm graded $In_{0.95}Ga_{0.05}N$	TAPC (30nm)	
7.5nm $In_{0.05}Ga_{0.95}N$ quantum well	TPDPES:TBPAH 10wt% (20nm)	
1nm graded $In_{0.95}Ga_{0.05}N$	ITO	
2nm $Al_{0.05}Ga_{0.95}N$ Barrier	Glass or Plastic	
3 μm $n-GaN$		
1.3 μm $n-GaN$		
25nm GaN buffer		
Sapphire substrate		

GaN LEDs

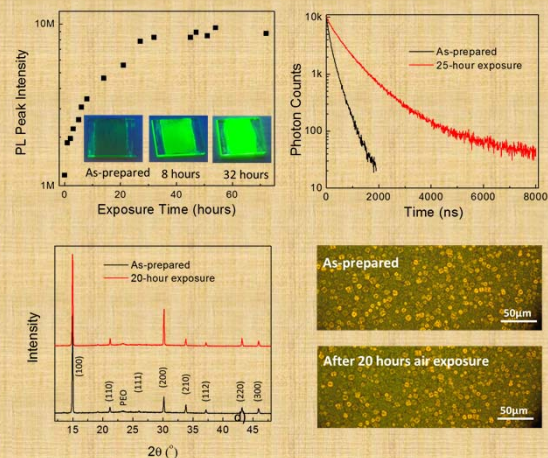
OLEDs

Perovskite LEDs

Fully Printed Perovskites LEDs



Air/Moisture Resistance



Large Scale Printing



Multicolor and Flexible LEDs



References

1. S. G. R. Bade, Z. Yu et.al, Fully Printable Organometal Halide Perovskite/Poly(ethylene oxide) Composite Thin Films, *ACS Nano*, 2016
2. J. Li, Z. Yu et. al, Single layer Light Emitting Diodes Using Organometal Halide Perovskite/ Poly(ethylene oxide) Composite Thin Films, *Advanced Materials*, 2015

Fund Supports

