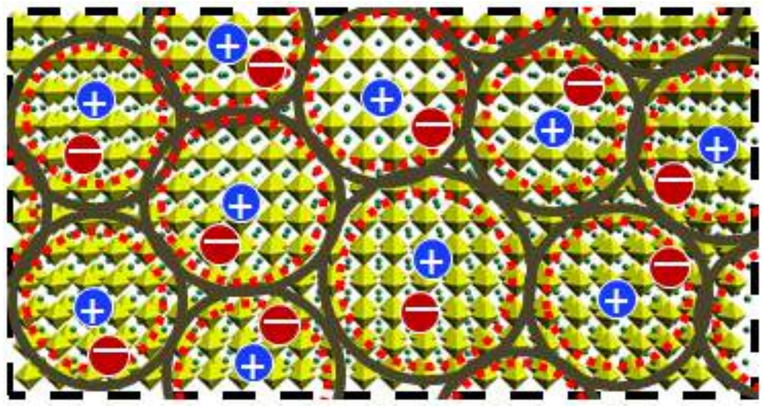
Metal Halide Perovskite Polycrystalline Film Technology

Tae-Woo Lee

Department of Materials Science and Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea
E-mail : twlees@snu.ac.kr

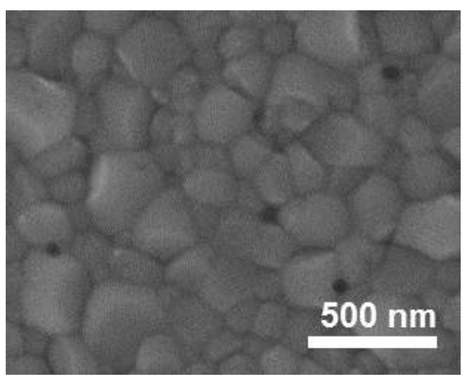
Research Background

Metal Halide Perovskite Polycrystalline Film

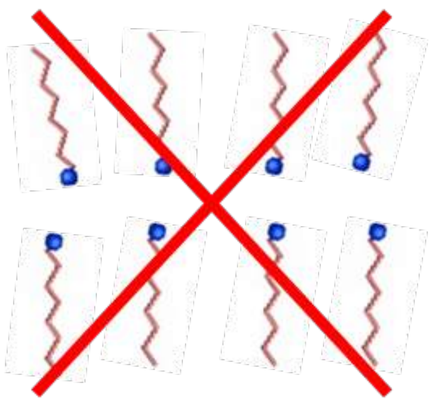


- **Film formation by spin-coating of precursor solution**
- **Grain size reduction is required**
  - → **Spatial confinement of excitons or charge carriers**
  - → **Improvement in luminescence efficiency**

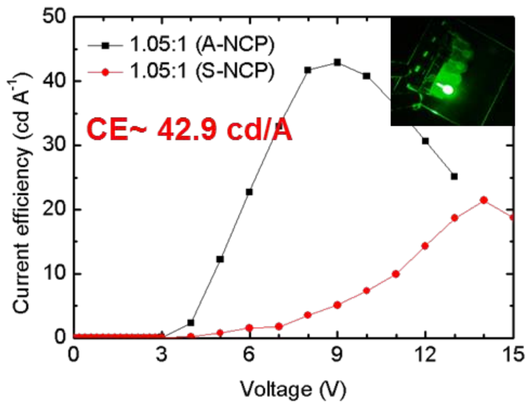
Advantages



- Simple film-forming process
- Full-coverage films



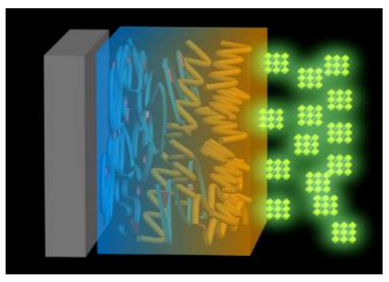
- No need for insulating ligands



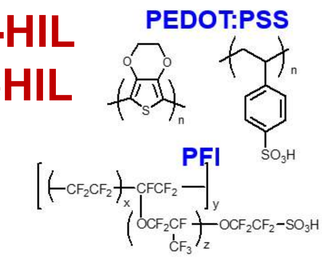
- High EL efficiency was already demonstrated

Technology

❖Self-organized conducing polymers



Buf-HIL
AnoHIL

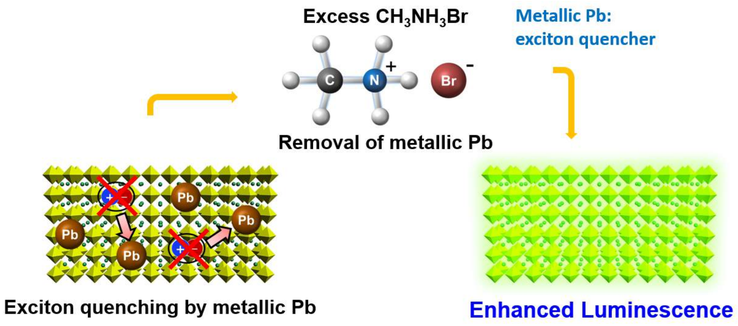


- **Composed of PEDOT:PSS and perfluorinated ionomer (PFI)**
- **Versatility: buffer hole injection layer and polymer electrodes**
- **Especially suitable for perovskite LEDs because PFI on top of conducing polymer layers can block luminescence quenching.**
- **Significantly increase device efficiency and brightness**

❖Related paper

Science 2015, 350(6265), 1222-1225; Advanced Materials 2015, 27(7), 1248-1254; Advanced Materials 2017, 29(31), 1700579

❖Removal of luminescence quenchers

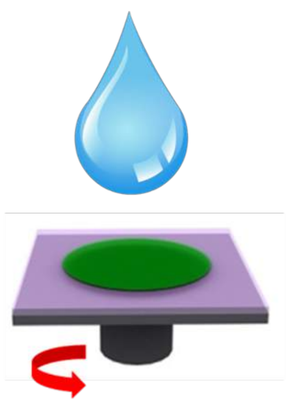


- **Metallic Pb atoms in perovskite layers can act as strong luminescence quenchers.**
- **We prevented the formation of metallic Pb atoms that cause significant exciton quenching through small increase in MABr molar proportion.**

➢ Related paper

Science 2015, 350(6265), 1222-1225

❖Nanograin engineering

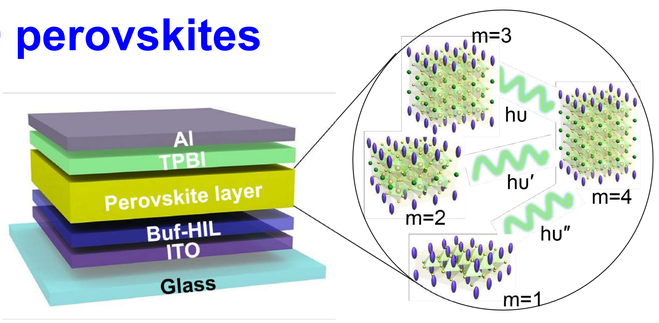


- **Nanocrystal pinning (NCP) method: highly volatile nonpolar solvent (*e.g.,* chloroform) washed out the "good" solvents (e.g. DMSO), and causes pinning of nanocrystals by inducing fast crystallization.**
- **NCP methods decrease perovskite grain sizes, improve film morphology and thereby increase efficiency of perovskite LEDs.**

❖Related paper

Science 2015, 350(6265), 1222-1225

❖Quasi-2D perovskites



- **2D perovskites have higher exciton binding energy and stability, but limited charge transport property compared to 3D counterparts.**
- **Quasi-2D perovskites of an optimal 2D-3D ratio have quantum confinement effect while maintaining moderate charge transport ability.**
- **Furthermore, film morphology can be improved and trap density can be decreased, yielding high device efficiency.**

❖Related paper

Advanced Materials 2016, 28(34), 7515–7520

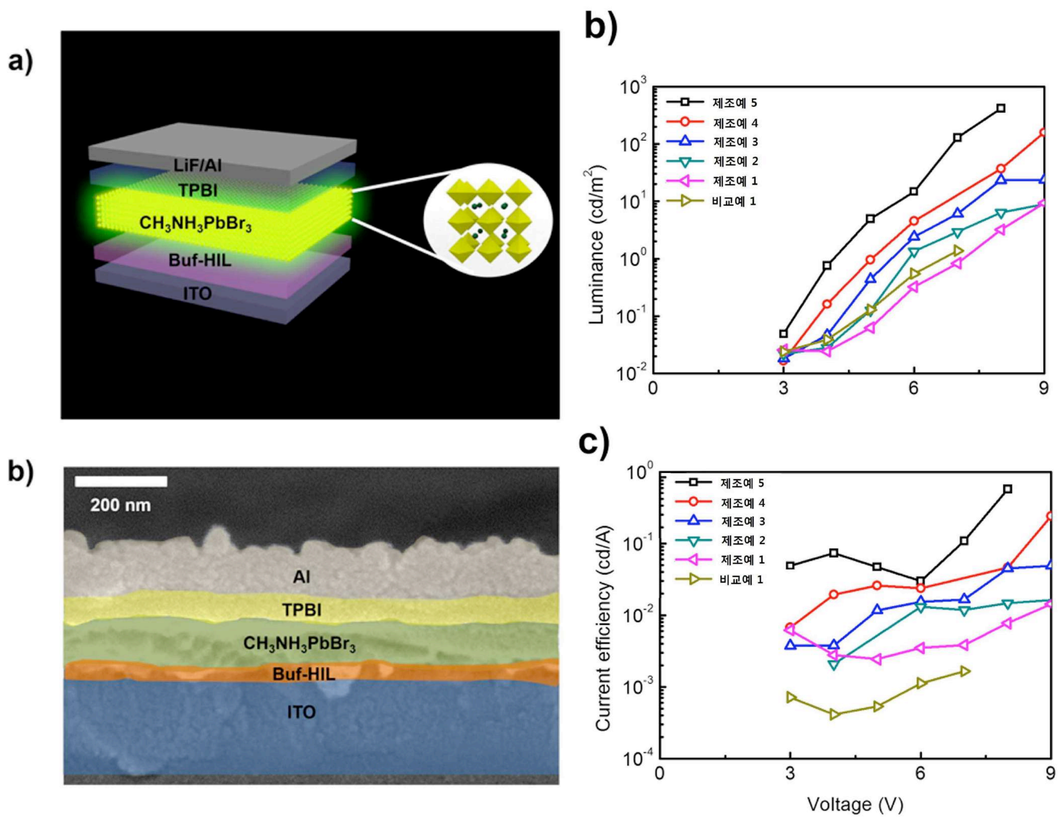
Metal Halide Perovskite Polycrystalline Film Technology

Tae-Woo Lee

Department of Materials Science and Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea
E-mail : twlees@snu.ac.kr

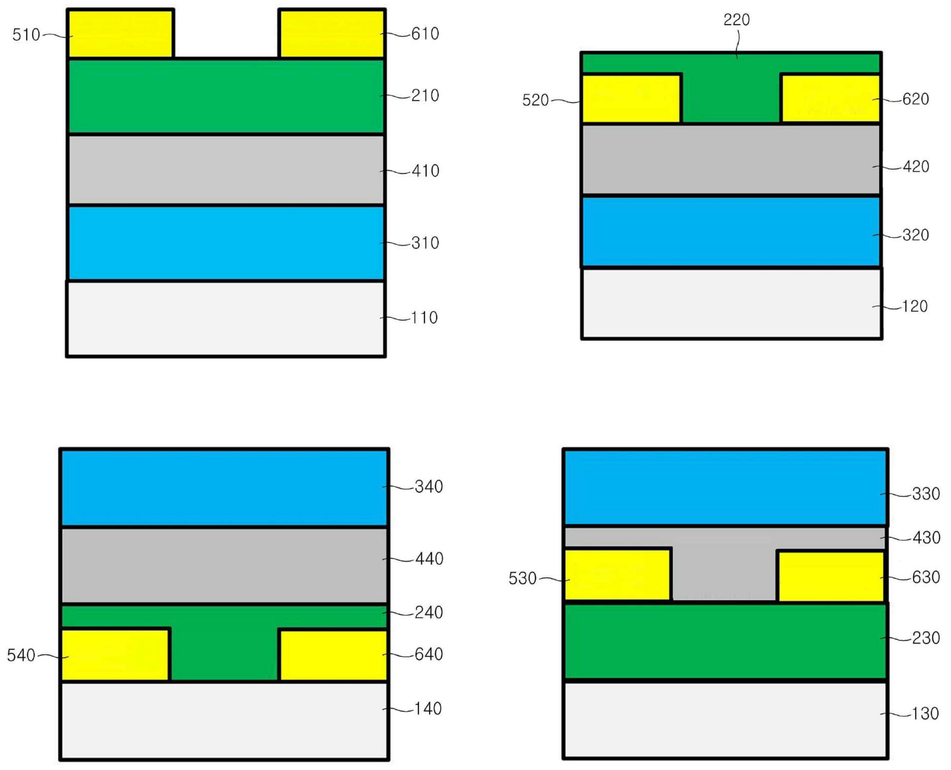
Patents

1. T.-W. Lee, S. H. Im, Y.-H. Kim, H. Cho, "Perovskite light emitting device including exciton buffer layer and manufacturing method thereof", Application: 10-2015-0156177, Korea (2015.11.06), Registration: 1017034510000 (2017.01.13)



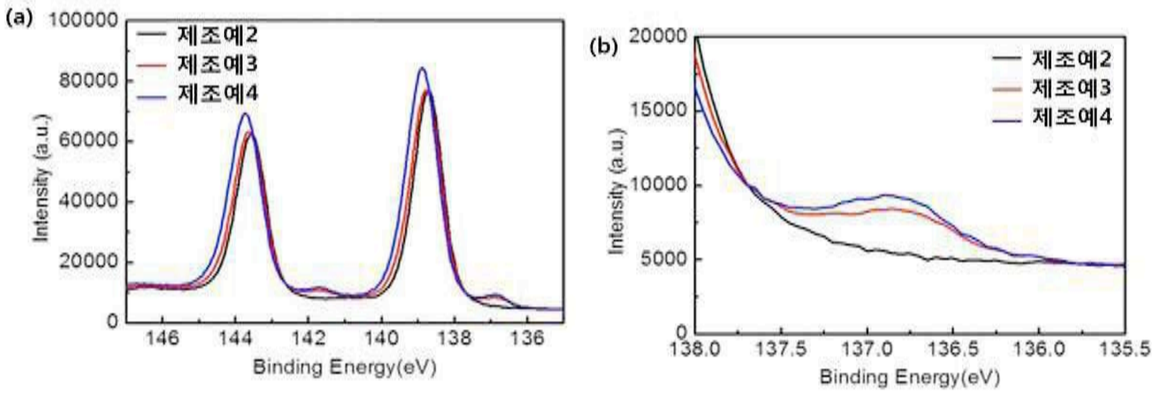
- 페로브스카이트 물질에서의 엑시톤의 퀜칭을 방지하기 위한 **엑시톤 버퍼층 (exciton buffer layer)**의 도입을 통해 **발광 효율 및 휘도가 개선된 유무기 하이브리드 페로브스카이트 또는 무기금속 할라이드 페로브스카이트 기반 발광 소자**를 제공

2. T.-W. Lee, C. Wolf, Y.-H. Kim, H. Cho, "Organic-inorganic hybrid perovskite light emitting transister and method of fabricating thereof", Application: 10-2015-0014675, Korea (2015.01.30), Registration: 10-16556480000 (2016.09.01)



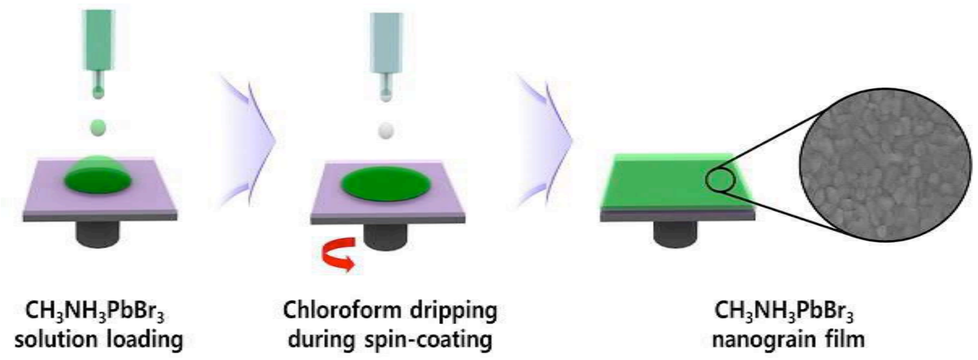
- **색순도 및 스위칭 특성을 향상**시킬 수 있고, **제조 비용을 절감**시킬 수 있는, **새로운 방식의 유무기 하이브리드 발광체 기반의 발광 트랜지스터** 및 이의 제조방법을 제공

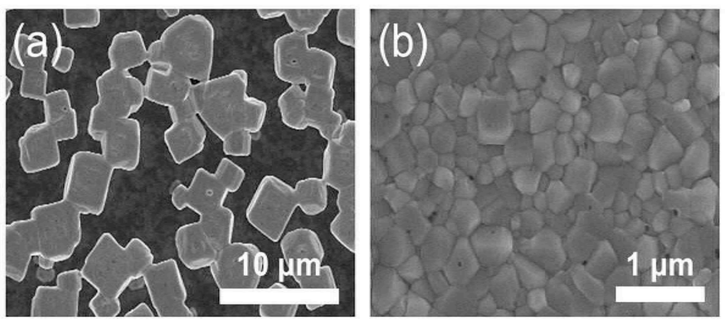
3. T.-W. Lee, S. H. Im, H. Cho, "Composition-controlled organic/inorganic hybrid perovskite light-emitting diodes and manufacturing method thereof", Application: 10-2015-0058867, Korea, (2015.04.27), Registration: 1017293900000 (2017.04.17)



- **퀜처 (금속성 납 원자) 제거를 통한 엑시톤 소멸 방지 공정**을 이용하여 **발광효율 및 휘도가 향상된 유무기 하이브리드 페로브스카이트 발광다이오드 및 이의 제조방법**을 제공

4. T.-W. Lee, S. H. Im, H. Cho, "organic/inorganic hybrid perovskite light-emitting layers using nanocrystal pinning process and manufacturing method thereof", Application: 10-2015-0058891 (2015.04.27)





- **나노결정 고정화 공정**을 통해 페로브스카이트 **박막의 균일도를 높이고 결정의 크기 및 패킹 밀도를 조절**하여, 향상된 효율 및 휘도를 가진 유무기 하이브리드 페로브스카이트 발광층 및 이의 제조방법을 제공

Metal Halide Perovskite Polycrystalline Film Technology

Tae-Woo Lee

Department of Materials Science and Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea
E-mail : twlees@snu.ac.kr

Papers

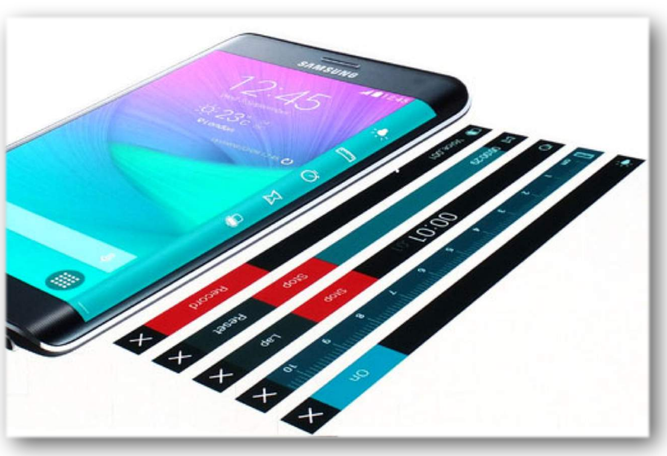
- **"Multicolored Organic/Inorganic Hybrid Perovskite Light-Emitting Diodes", Advanced Materials 2015, 27(7), 1248-1254**
- **"Overcoming the electroluminescence efficiency limitations of perovskite light-emitting diodes", Science 2015, 350(6265), 1222-1225**
- **"Metal halide perovskite light emitters", *Proc. Natl. Acad. Sci. U S A* 2016, 113, 11694.**
- **"Efficient Visible Quasi-2D Perovskite Light-Emitting Diodes", Advanced Materials 2016, 28(34), 7515–7520**
- **"Efficient Flexible Organic/Inorganic Hybrid Perovskite Light-Emitting Diodes Based on Graphene Anode", Advanced Materials, (2017), 29, 1605587**
- **"High-Efficiency Solution-Processed Inorganic Metal Halide Perovskite Light-Emitting Diodes", Advanced Materials 2017, 29(31), 1700579**

Applications

Curved TV

Digital screens and billboards

Smart phones

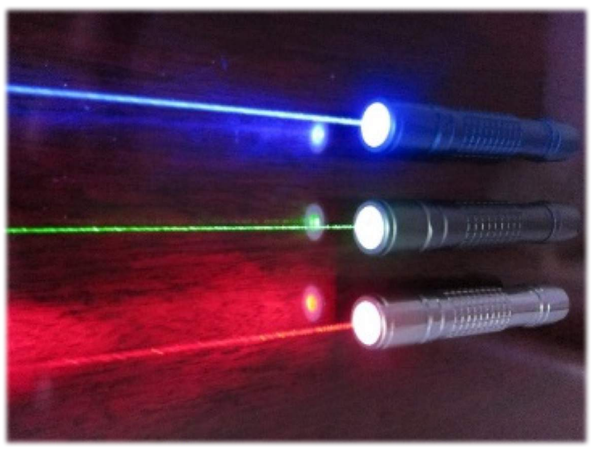


Flexible lighting

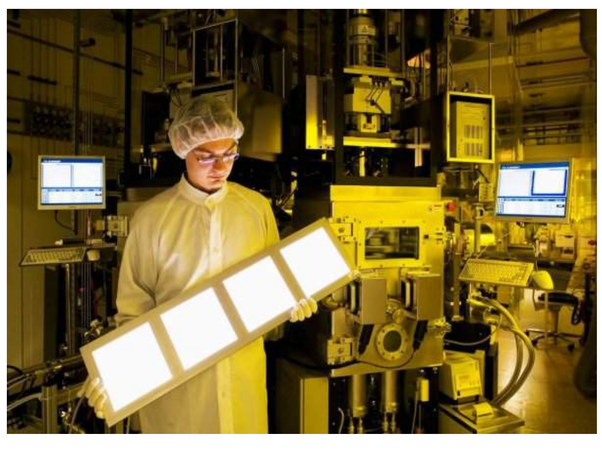
Automobile displays

Flexible displays

Laser



Illumination



Related Company

- **Display company**
- **Lighting company**
- **Light-emitting film company**

Source Technology

- **Our group has published frontier papers in this field and is trying to keep this world-leading status.**
- **We have 4 patent applications (Korea); three of them were registered.**