OURS/MCNAIR/CAMP Presentation:

Realizing 2D and 3D single-crystal perovskite devices

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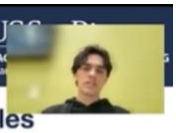
THE ENERGY CONVERSION CRISIS



There's a climate crisis and a strong need for renewables

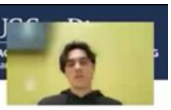
- *Perovskites* have shown optimal properties to be used as a material for solar cells, LEDs, lasers, photodetectors and many more.
- BUT there are still problems that need to be solved (Lifetime & Efficiency)
- MY GOAL: Research how we can integrate 3D or 2D perovskites into devices to solve these global issues

The State of the Art

Perovskite Solar Cells and LEDs

- Perovskite solar cells are slowly being commercialized and have efficiencies comparable to commercial solar (~21%)
- Perovskite LEDs (PeLEDs) have shown high color purity and efficiencies comparable to commercial displays in Red and Green

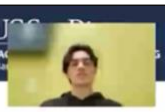
Perovskite Problems



Poor stability, efficiency, and lead toxicity

- Stability = “Shelf Life”
- Power Conversion Efficiency or External Quantum Efficiency
- Lead Toxicity or environmental friendliness

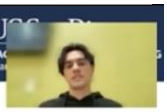
What does 2D mean?



A stack of pancakes with butter

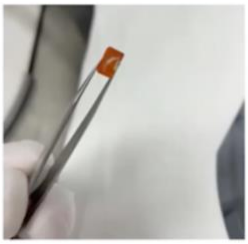
- A diamond is a *3D crystal*
- If you take single atomic layers of a crystal and stack them on one of another that is called a *2D crystal.*
- Separate each atomic layer with an organic ligand

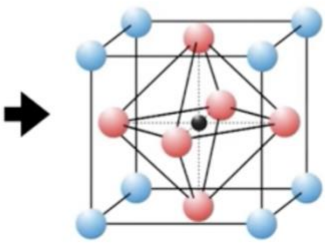
“3D” vs “2D”



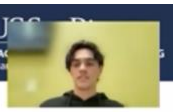
Subtle but very important

- 3D and 2D crystals can be grown to the same sizes but the way the atoms are arranged is fundamentally different in each





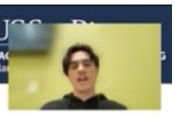
Problems I Addressed



Efficiency and Chemical Stability

- Single crystal devices and Quasi-2D devices are promising avenues to producing both efficient and stable devices.
- There needs to be effective and reproducible way to build these devices
- My goal is to demonstrate efficient and stable PeLEDs

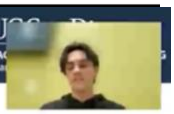
Methods for Solving



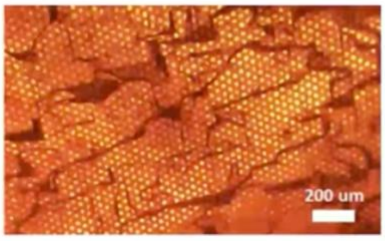
Homoepitaxial Growth of 3D Single Crystal

- Polycrystalline vs Single Crystal
- A device built from only one crystal does not have the same interruptions or defects as a device built from multiple tiny crystals

Single Crystal Device



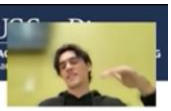
Controlled Thickness of Perovskite layer



Perovskite substrate with chromium mask

Method developed by Sheng Xu research group (Yusheng Lei & Yimu Chen)

How do we build devices?

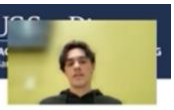


Polycrystalline Device (Quasi-2D)

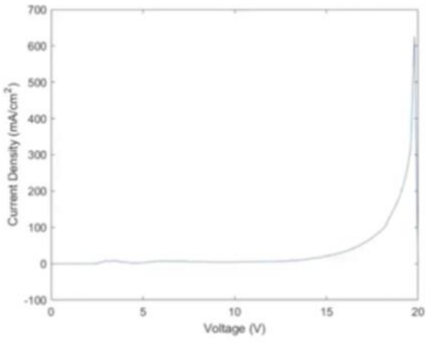
Layers of Device (from top to bottom)

Silver Paste/Aluminum (Electrode)
F8 (Election transport layer)
Quasi-2D Perovskite
PEDOT:PSS or PVK (Hole transport layer)
ITO
Glass

A Bright Quasi-2D PeLED



J-V curve of PeLED



Future Directions

Develop Single Crystal 3D Devices

Develop Single Crystal 2D devices

Skills I have learned

Thin-Film Deposition Methods

- Spin Coating
- Sputtering
- Electron Beam Evaporation
- Thermal Evaporation

Device Characterization

- EQE determination
- PCE Determination
- Measuring nanometer scale thicknesses
- Photoluminesence Quantum Yield

Thank you

Thank you Professor Xu and Chengchangfeng Lu

Thank you to the UCSD McNair Program and CAMP

Feel free to reach out to me at

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