

Quantifying Mechanical Failure in Perovskite Semiconductors Using Shear Testing

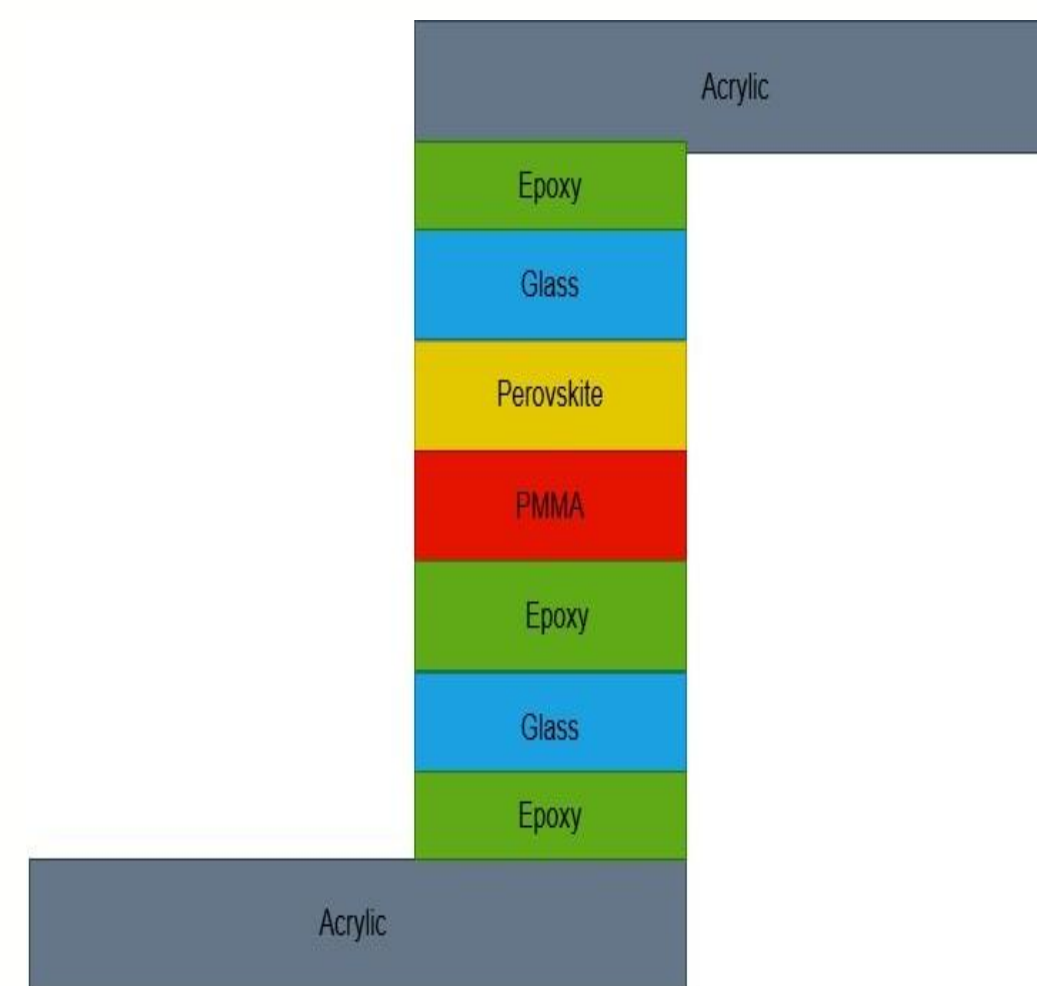
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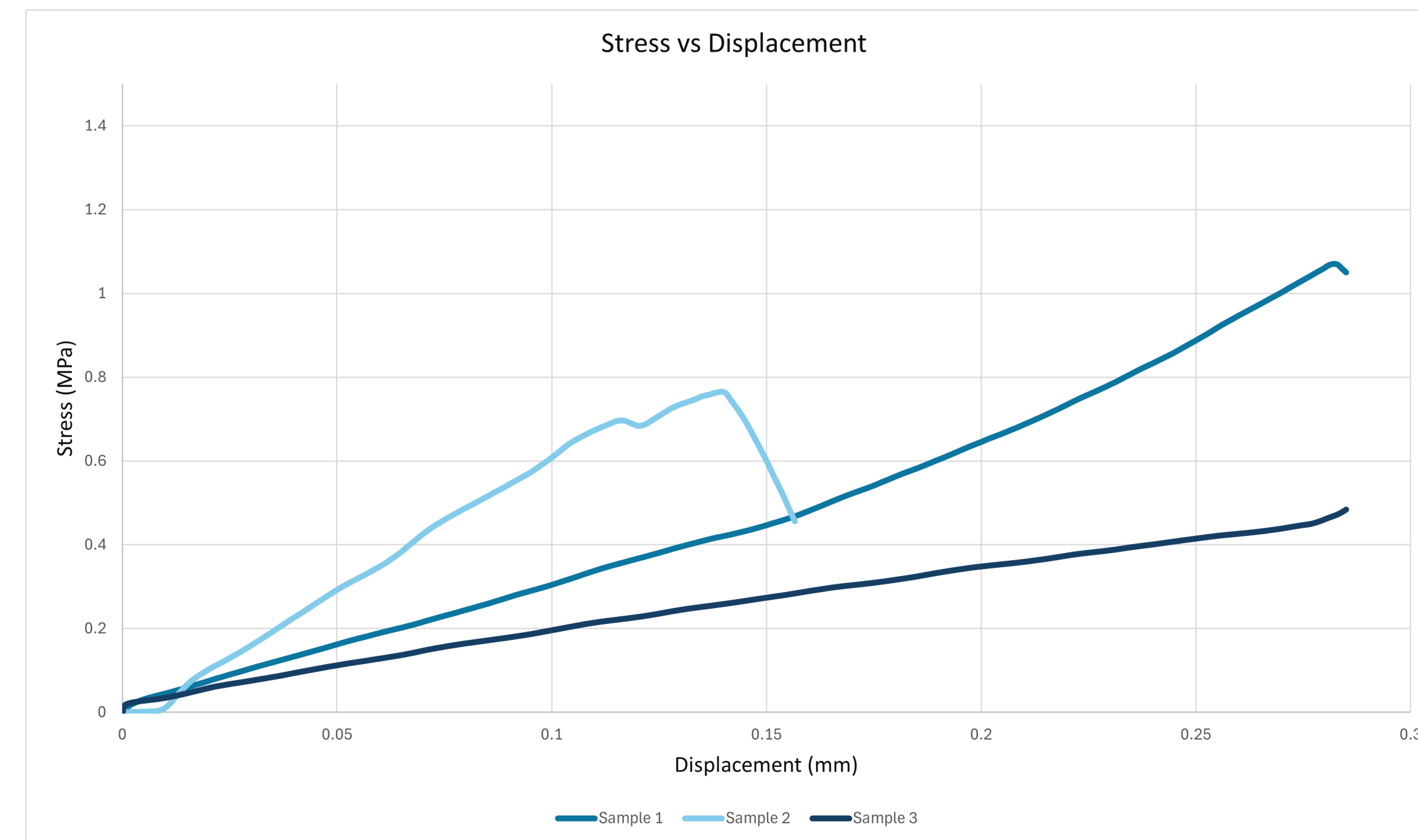


Background



Mode II (Shear) is when surfaces slide over one another [2]. Shear strength is the amount of force applied before a material delaminates. This is the primary cause of edge debonding, where the film separates at the edges [1]. Metal halide perovskites are promising for solar cells due to their high efficiency and low-cost fabrication. However, they are limited by mechanical fragility and poor interfacial adhesion, which leads to delamination. This research characterizes Mode II sliding properties to understand the mechanical stability of the perovskite-glass interface.

Results



Sample 1: Adhesion failure at glass/epoxy interface (higher surface roughness)

This is a sample after fracturing occurred. The two sides of the sample have separated on the acrylic/epoxy/glass layer due to the bond between acrylic/glass being weaker than the bond of the perovskite on glass. The perovskite has a shear strength greater than the value measured and did not delaminate.

Future Work

- Continue quantifying mechanical failure in perovskite semiconductors using shear testing
- Shear testing on a full perovskite configuration, including the additional layer in a solar cell device
- Try different epoxies and use sandpaper on the acrylic to roughen the bond

Research Method

Preparation:

- Prepared samples using the configuration glass/perovskite/PMMA/epoxy/glass.
- Cut acrylic 1inch by 3 inches, then 5-min epoxy acrylic on both sides of the sample

Testing:

- Align Acrylic on to the Instron 68TM-5 and adjust position of fixtures
- Lap Shear Test on Instron 68TM-5 begins displacing the sample at 5 mm/min and the machine will stop when failure has occurred, meaning the layers have separated (delamination).

Conclusion

Initial testing had significant optimization of sample configuration. The early designs lacked proper gripping supports, poor adhesion/premature failure, and weak configurations. The final configuration (glass/perovskite/PMMA/epoxy/glass) with acrylic handles bonded allowed for shear testing to be performed and showed that the bond between acrylic and glass was weaker than of the perovskite.

References

- [1] Li, M., et al. (2024). Strategies to improve the mechanical robustness of metal halide perovskite solar cells. *Energy Advances*, 3(1), 273–280. <https://doi.org/10.1039/D3YA00377A>
- [2] Sun, W., Zhao, J., Wu, S., Guo, W., & Hou, Z. (2024). The relationships between tensile strength, mode I and mode II fracture toughness of rock: An empirical and microcracking perspective. *Heliyon*, 10(18), e37438. <https://doi.org/10.1016/j.heliyon.2024.e37438>