Visualization of the charge transfer and accumulation under illumination in different semiconducting materials

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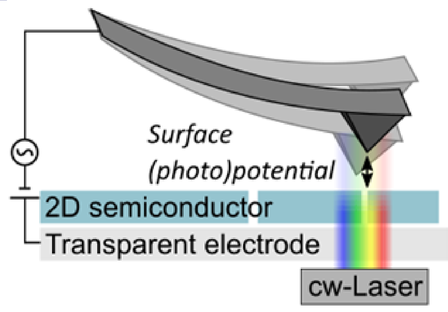
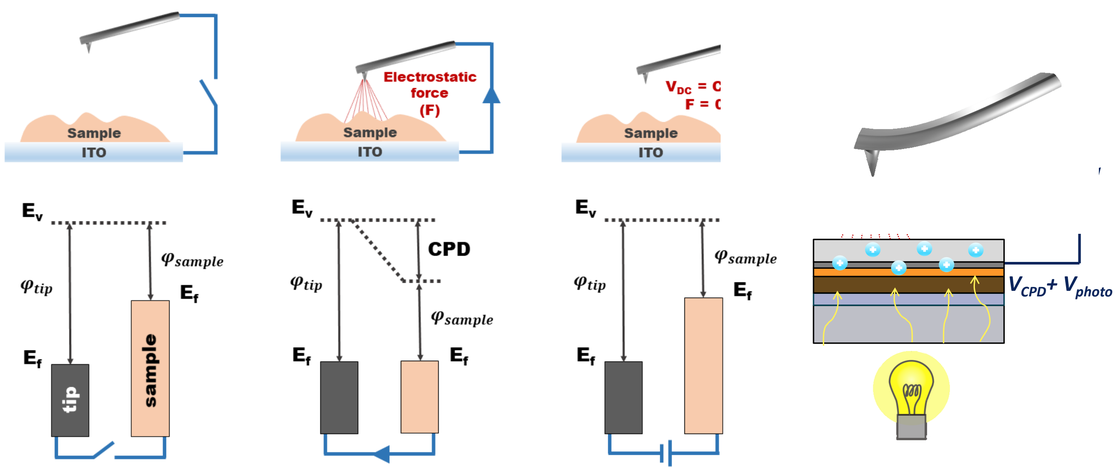
Introduction

Kelvin Probe Force Microscopy (KPFM) is a well-known method for detecting the local surface potential at the nanoscale. The combination of KPFM with confocal microscopy allows the simultaneous study of photoinduced carrier transfer in a semiconducting material. Here we have visualized the transfer/generation of charges in semiconducting materials under different illumination conditions.

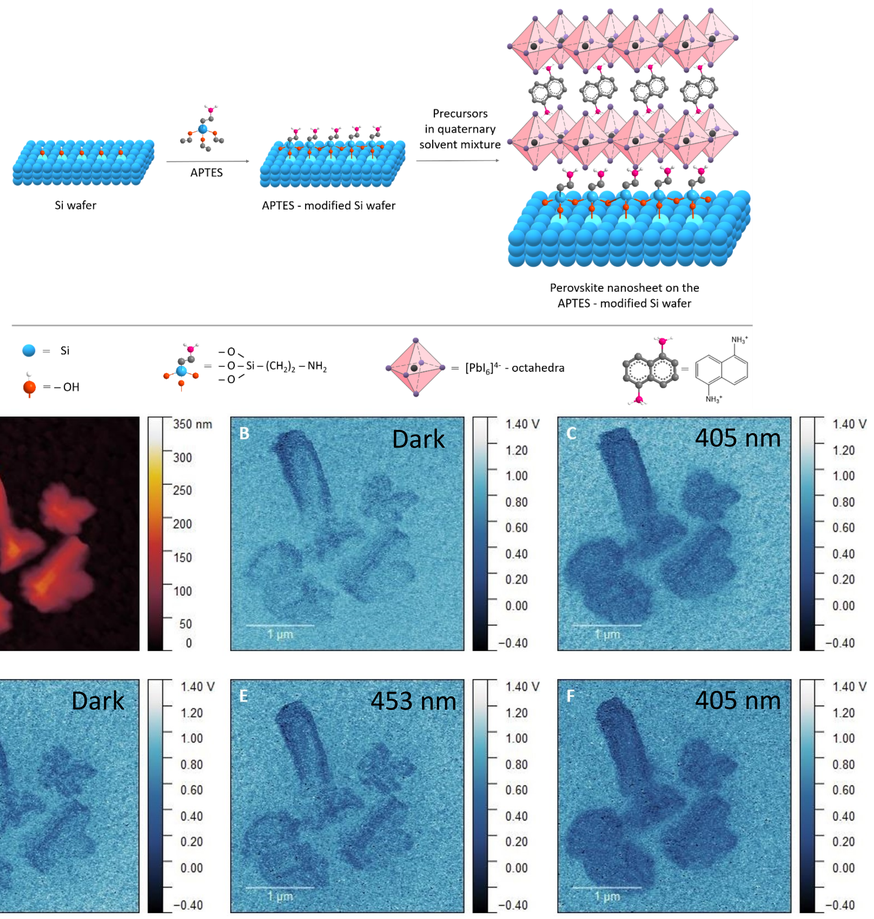


Schematic representation of the experimental setup

Working principle of KPFM



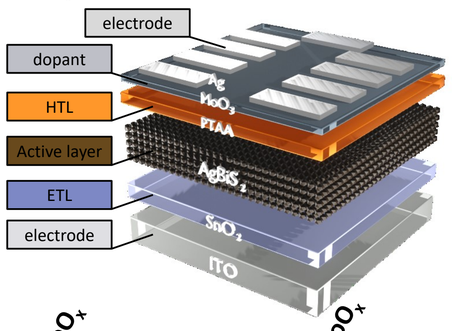
2D perovskite material

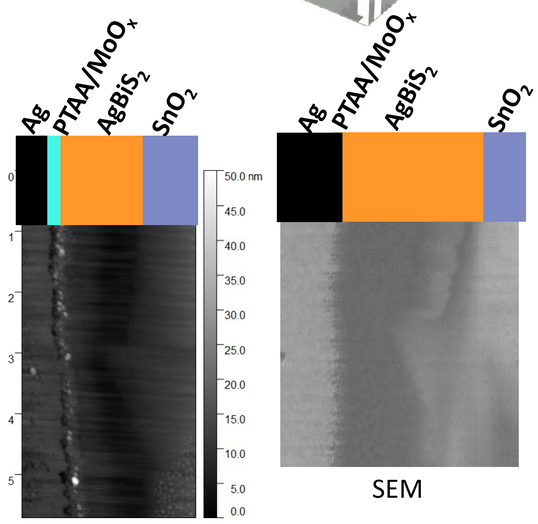


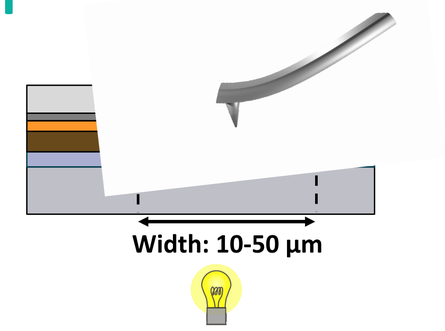
- Huge effect (0.2 V) on thick (250 nm) particles under 405 nm light.
- No effect under 458 nm
- Decrease in CPD indicates p-type semiconductor
- Trapped states

Solar Cell

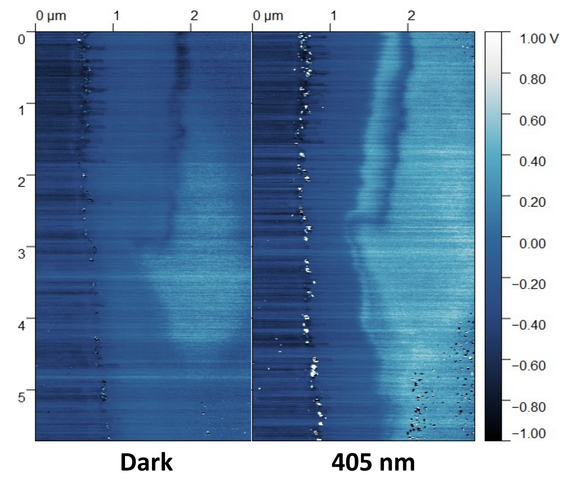
Record PCE 11%
Why?



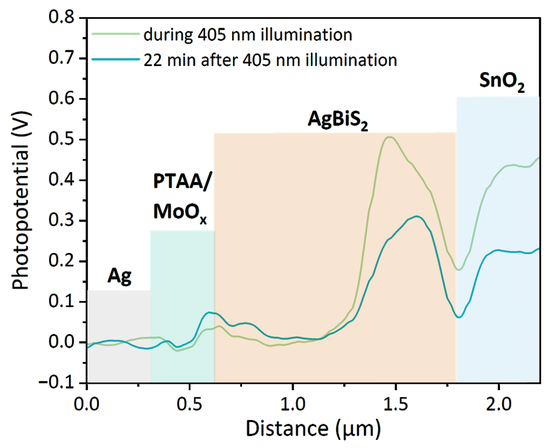


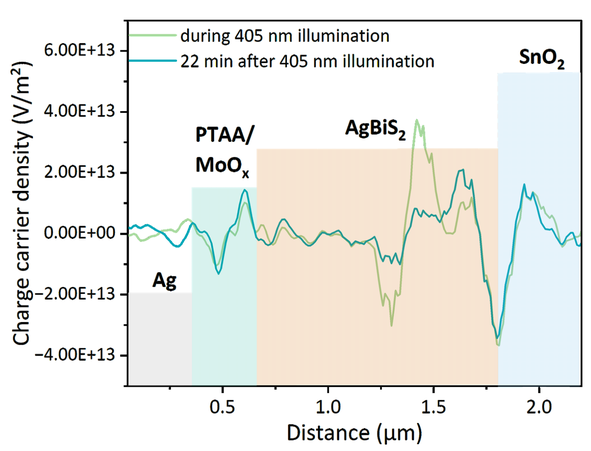


- Shallow angle tapered cross-sectioning allowed to artificially elongate the solar cell layer



- Increase of the potential in the active





- Accumulation of the positive charge in the active layer
- Elevated potential after 22 minutes (trapped states)
- Accumulation of charges at the ETL/Active layer interface (trapped states location)

Conclusions

The photocharging imaged via KPFM demonstrated that the novel 2D halide perovskite material is a p-type semiconductor and has a potential photodetector application. In the case of the QDs based solar cell cross section study, the implementation of the shallow angle tapered cross sectioning allowed to artificially elongate the solar cell layers to study each layer in operando. This approach revealed the accumulation of charges at the specific interface and in the future offer strategies for further device optimization. In addition, the visualization of the carriers in the device in operando can be crucial for understanding the intricacies of the physical processes occurring inside the device.

Acknowledgments

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