

Electronic Transport Properties of 3D Hybrid Perovskites

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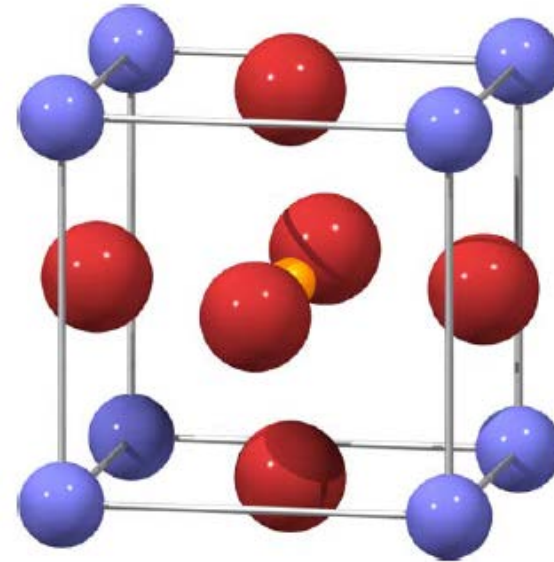
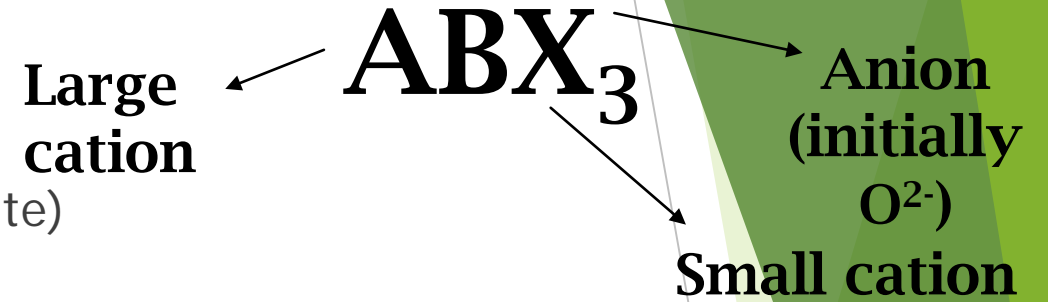
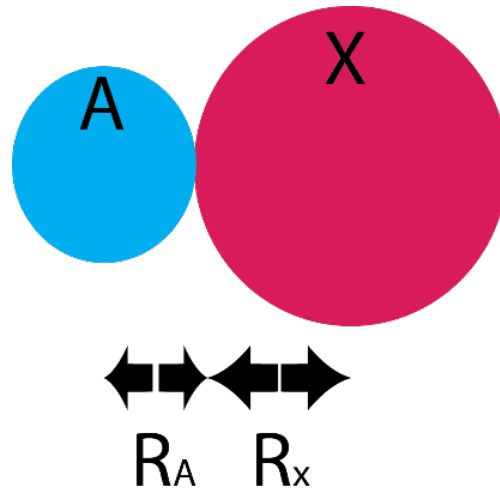
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What is a perovskite?

- ▶ Class of compounds in the form ABX_3 (calcium titanate)
- ▶ Goldschmidt's Tolerance Factor
- ▶ Hybrid Perovskite- A is organic and B is inorganic

$$t = \frac{\{R_A + R_X\}}{\{\sqrt{2}(R_B + R_X)\}}$$

R_i – ionic radial of ion i



A-Blue, B-Yellow, X-Red

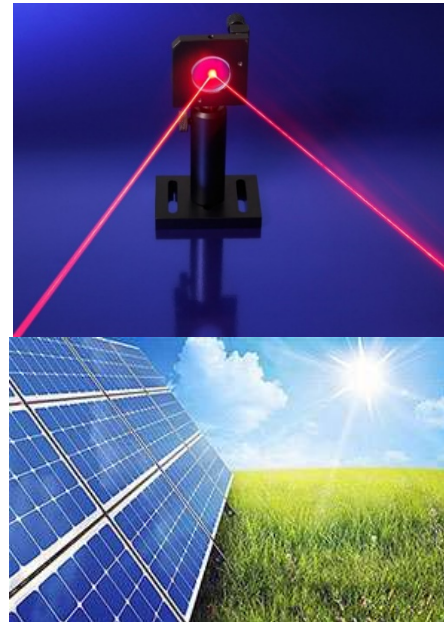
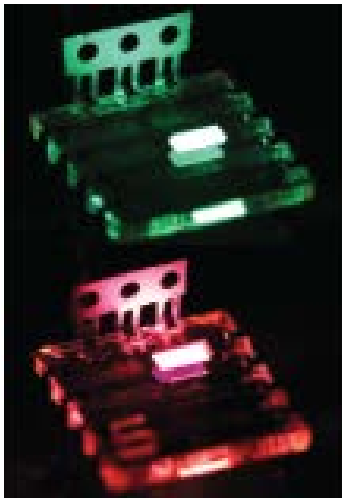
Orthorhombic ($t < 0.89$)
Cubic ($0.89 < t < 1$)
Tetragonal ($t > 1$)

Purpose of this experiment

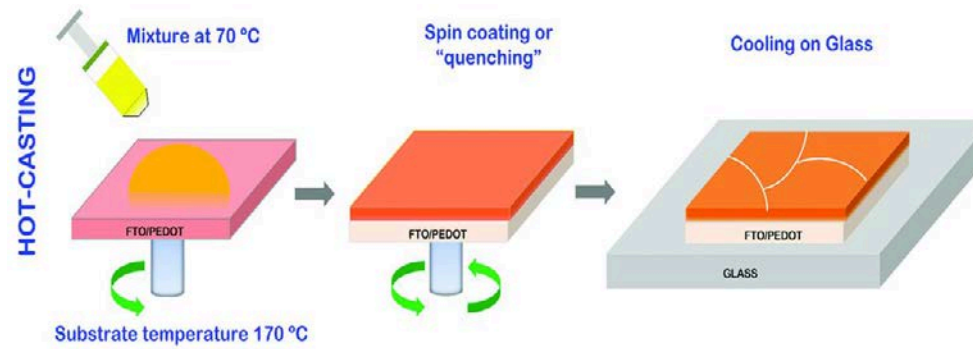
- ▶ To study perovskites as inert gas sensors
- ▶ To study optoelectronic properties

Why Hybrid Perovskites?

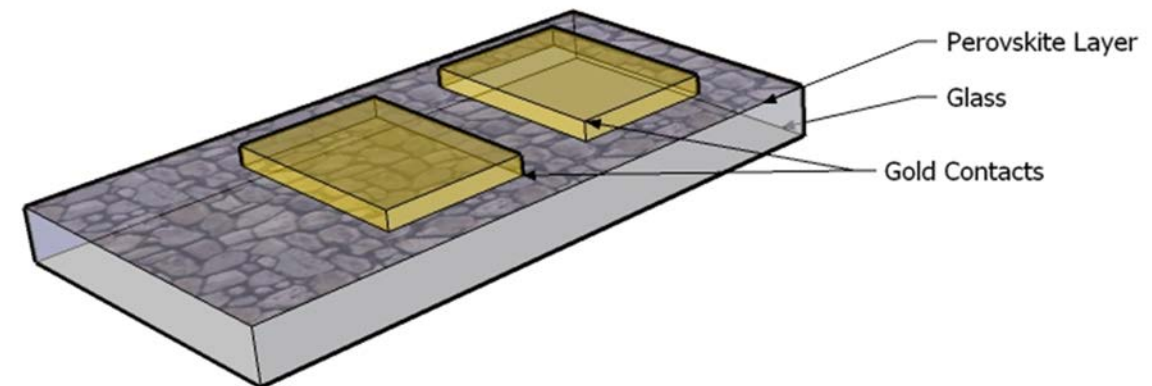
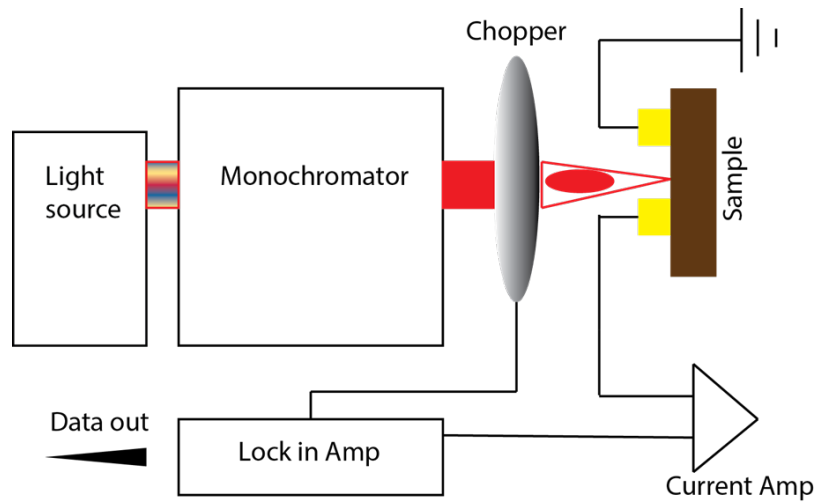
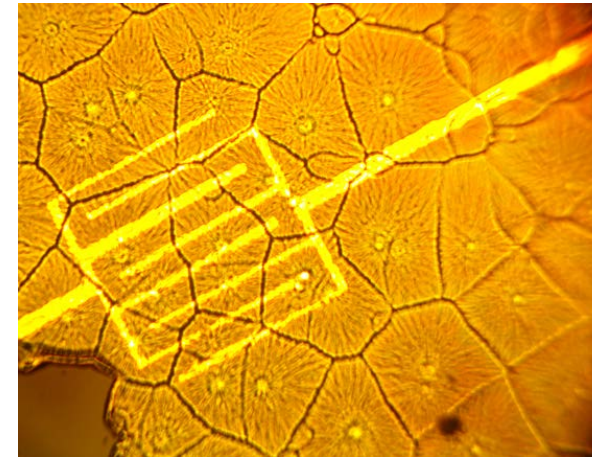
- ▶ Excellent semiconductors with optoelectronic properties
- ▶ Propensity for ionic conduction
- ▶ Have been used in LEDs, solar cells, lasers, photovoltaic devices



Methods



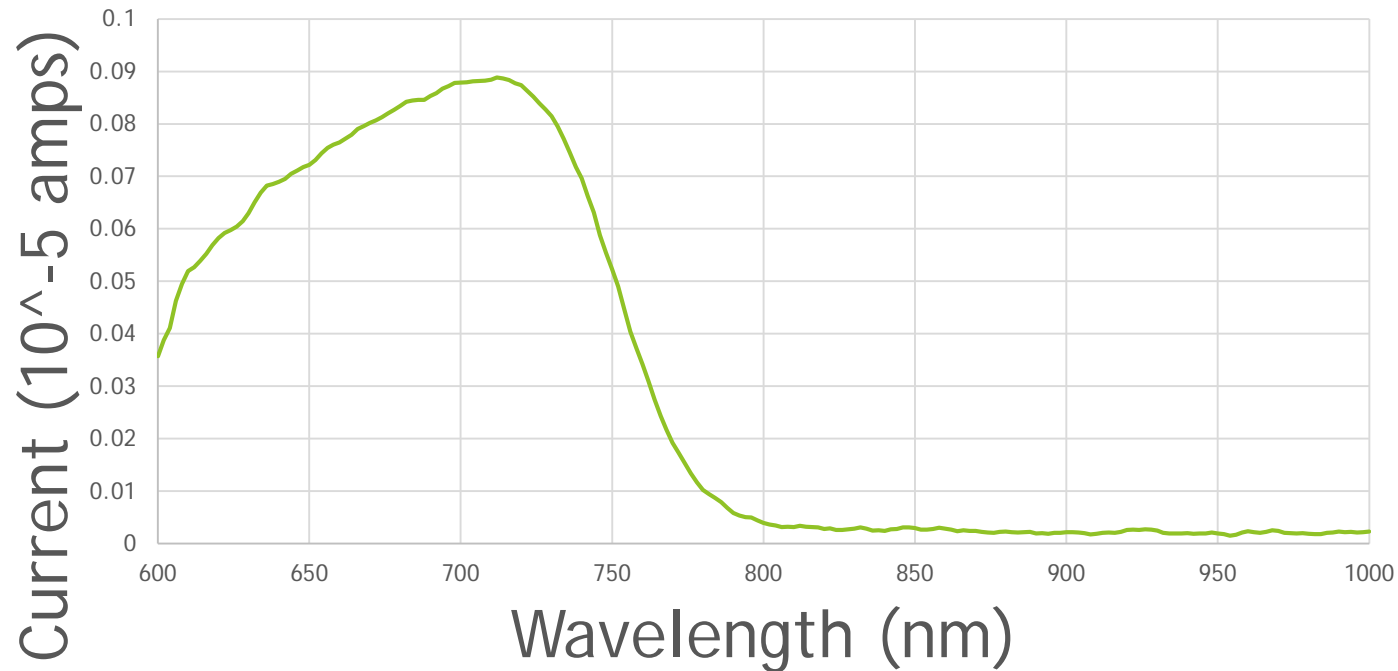
- ▶ Hot casting methyl ammonium iodide and lead iodide
- ▶ Monochromator is used as the light source
- ▶ Chopped AC light at set wavelength
- ▶ Vacuum, Helium, Nitrogen, Argon, and extra Light
- ▶ Photocurrent and IV measurements
- ▶ Exposed Perovskite to applied bias over time



Results

- ▶ Photocurrent scan shows 730 nm strongest signal
- ▶ Band edge gap consistent with perovskites

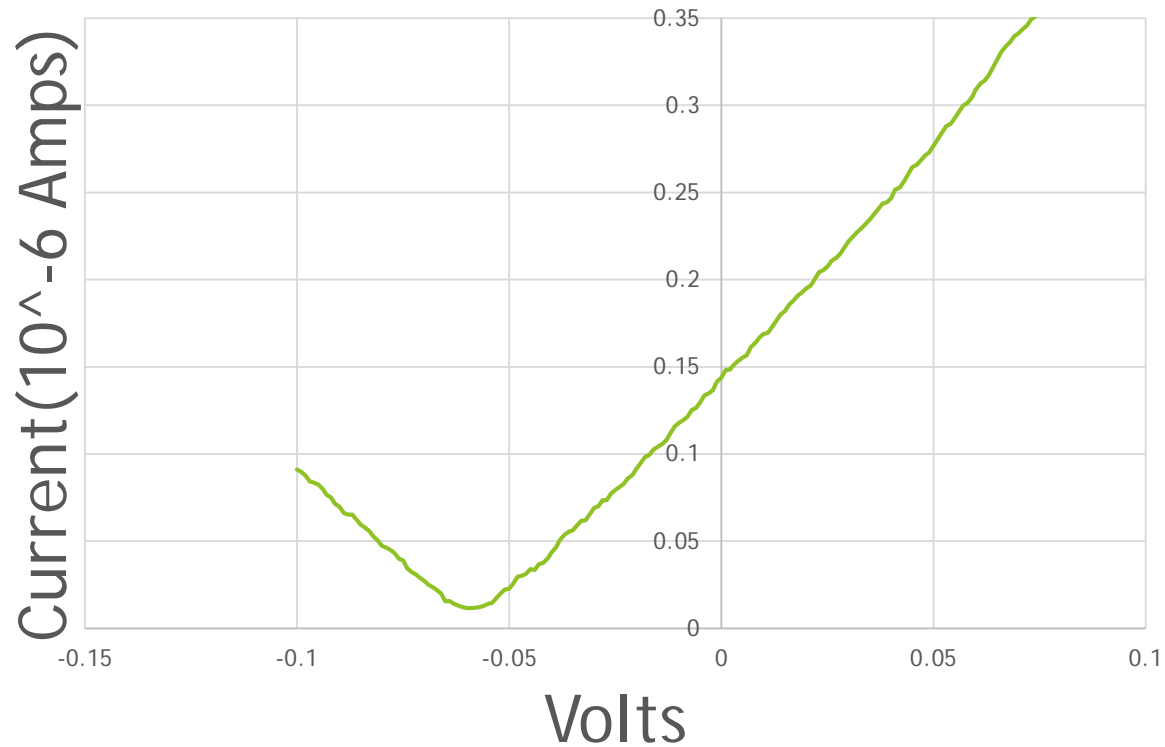
Current vs. Wavelength



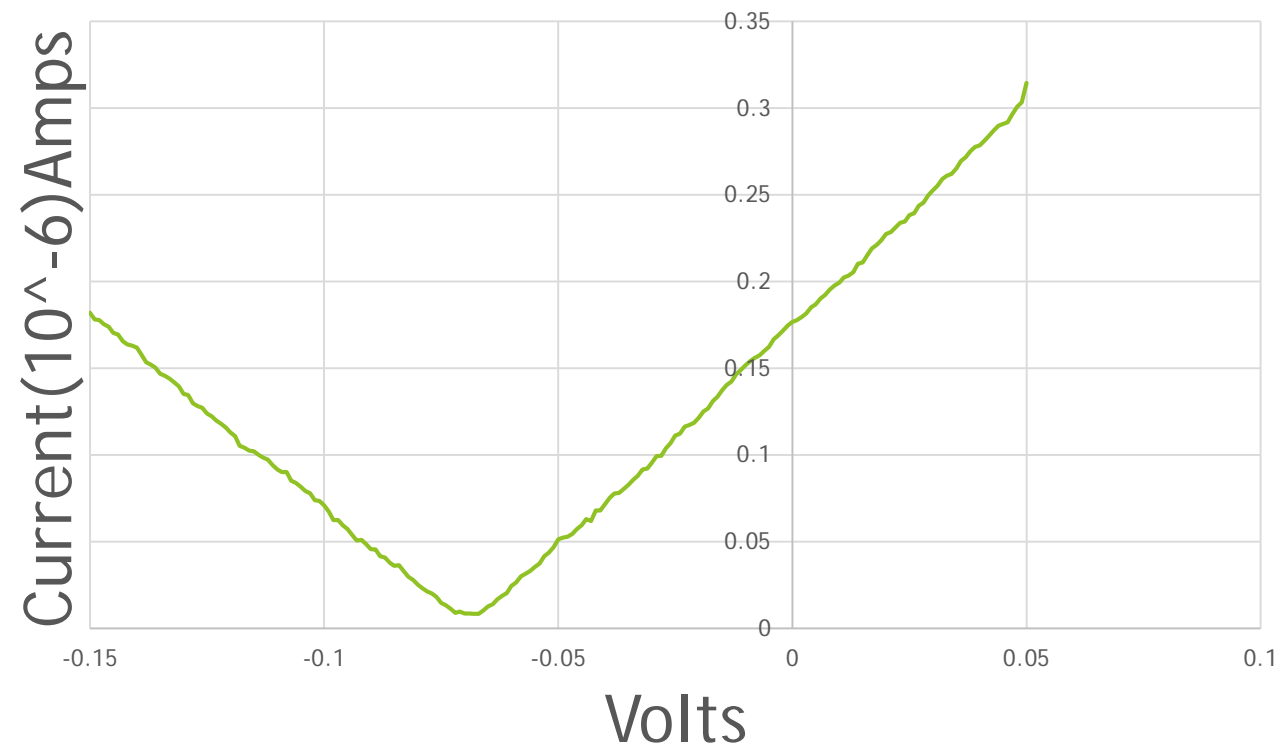
Extra Light results

- ▶ With an extra light, the current increases
- ▶ Built in potential is shifted

No Light



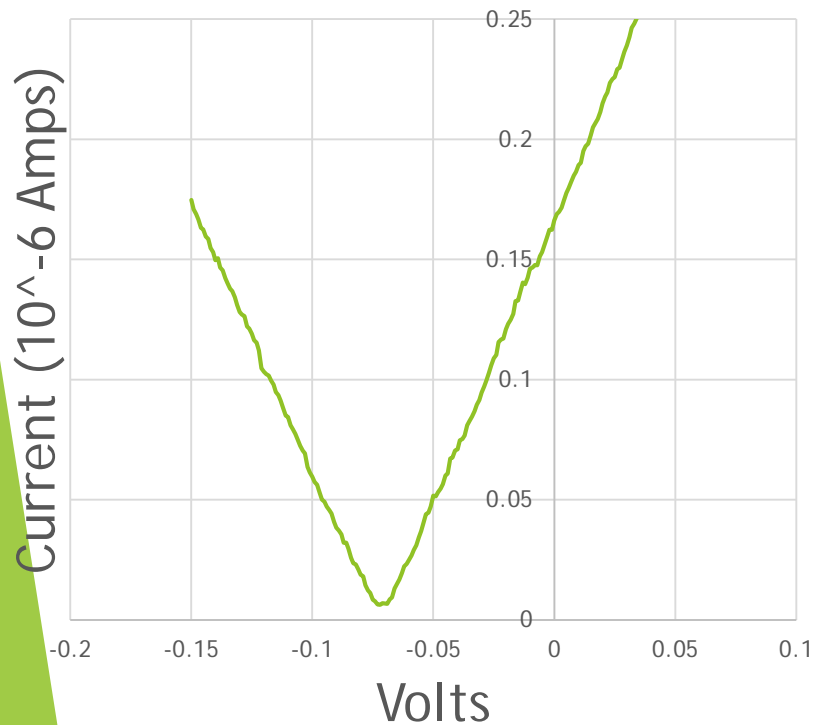
Light



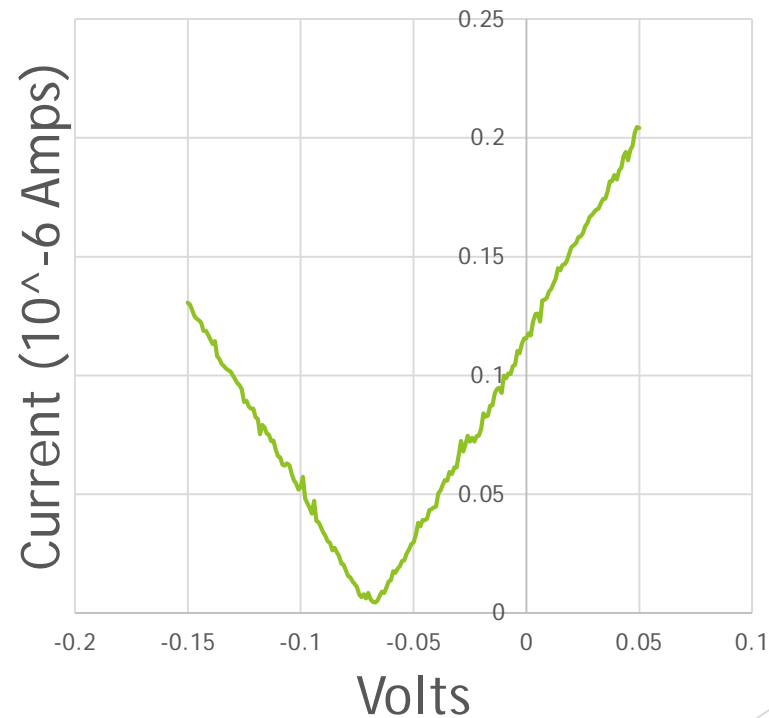
Helium IV Measurements

- ▶ Helium has virtually no effect on built in potential and current
- ▶ Helium + Light also has virtually no effect
- ▶ Atomic mass = 4.0

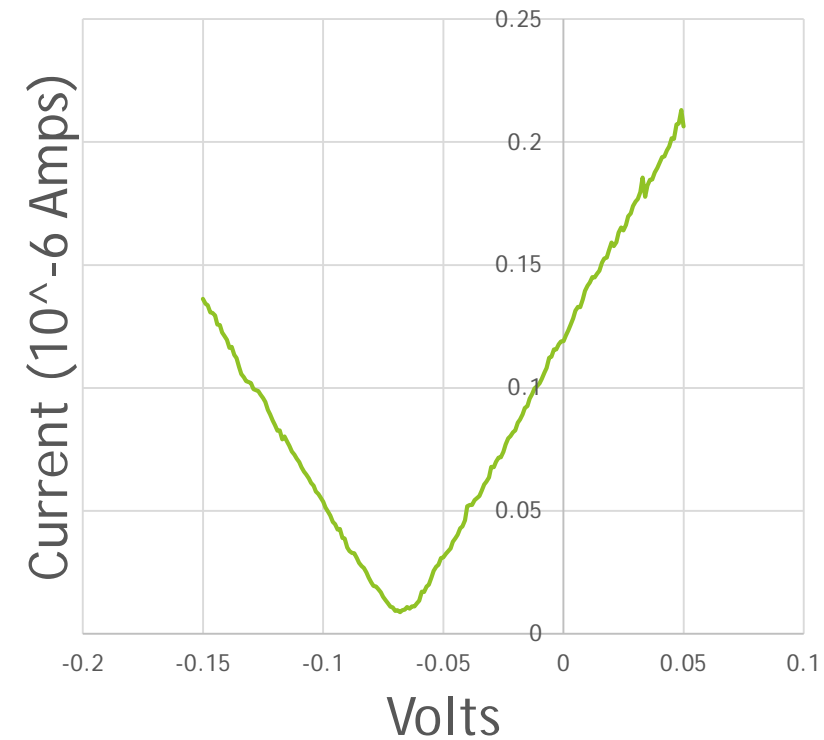
Vacuum



Helium



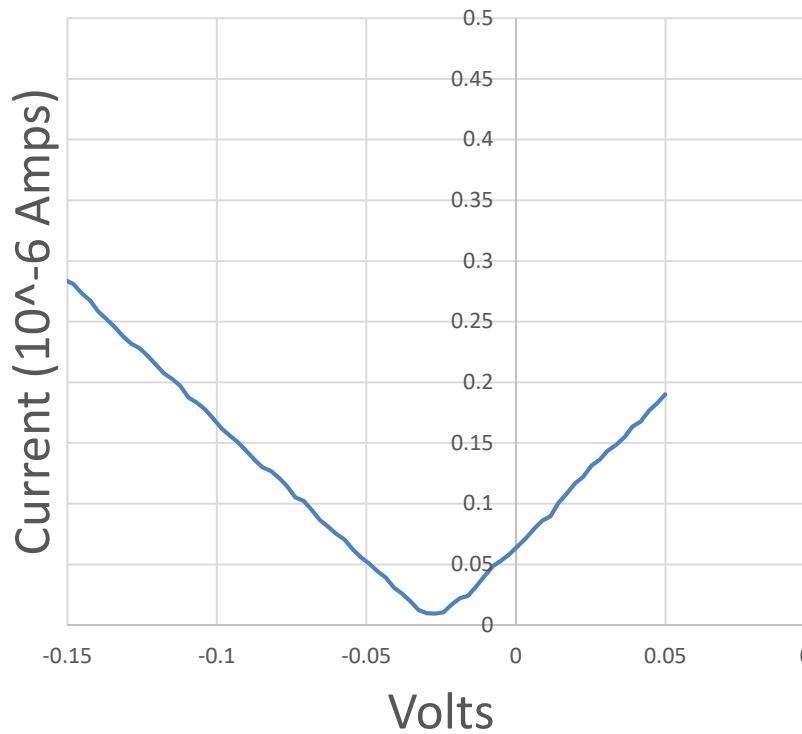
Helium + Light



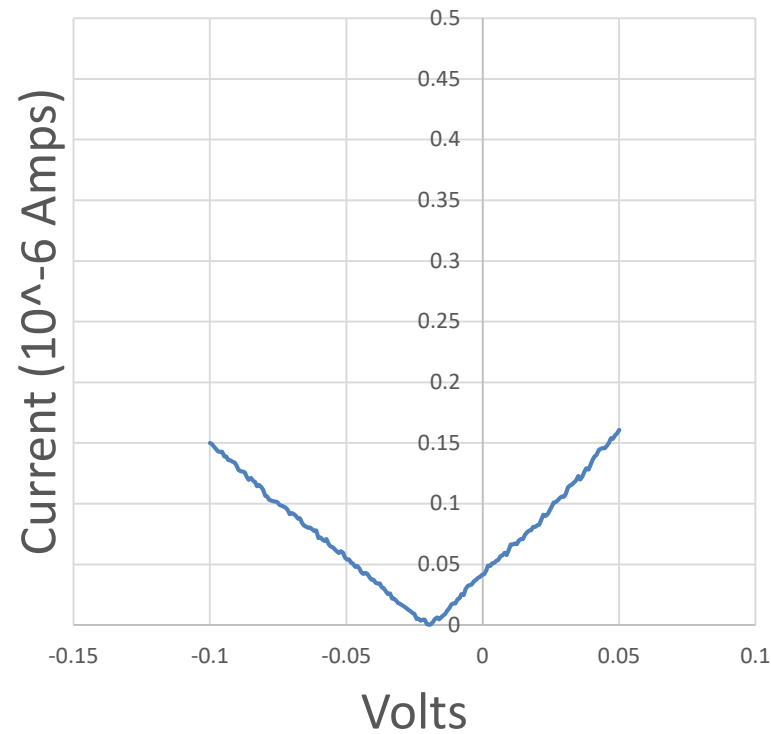
Nitrogen IV Measurements

- ▶ Built in potential changes
- ▶ Current increases
- ▶ Nitrogen AMU (Diatomic) = 28

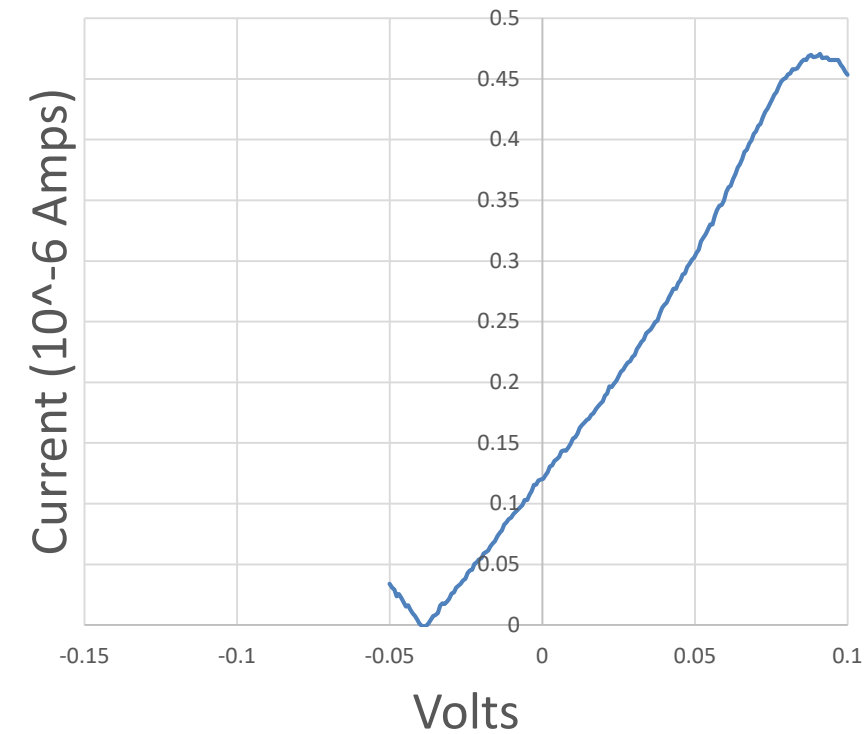
Vacuum



Nitrogen



Nitrogen + Light

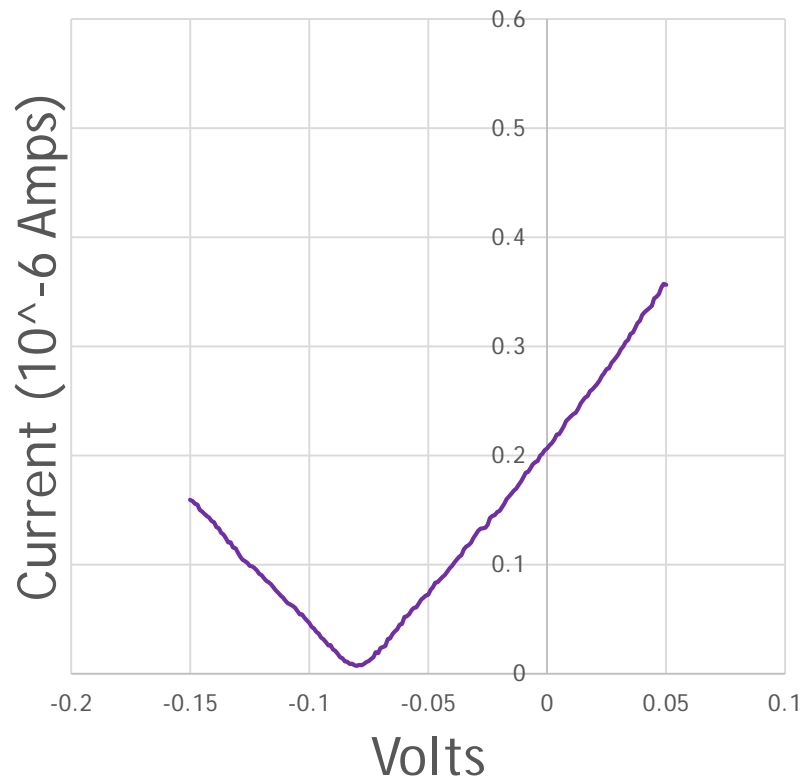


Argon IV Measurements

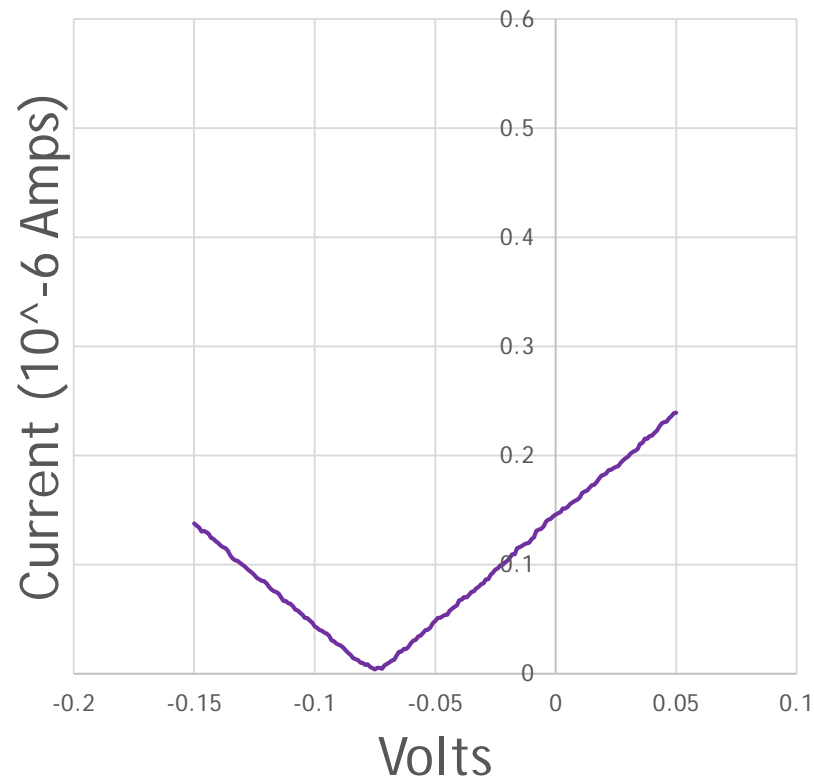
- ▶ Huge change in current and built in potential with argon
- ▶ Argon AMU = 40



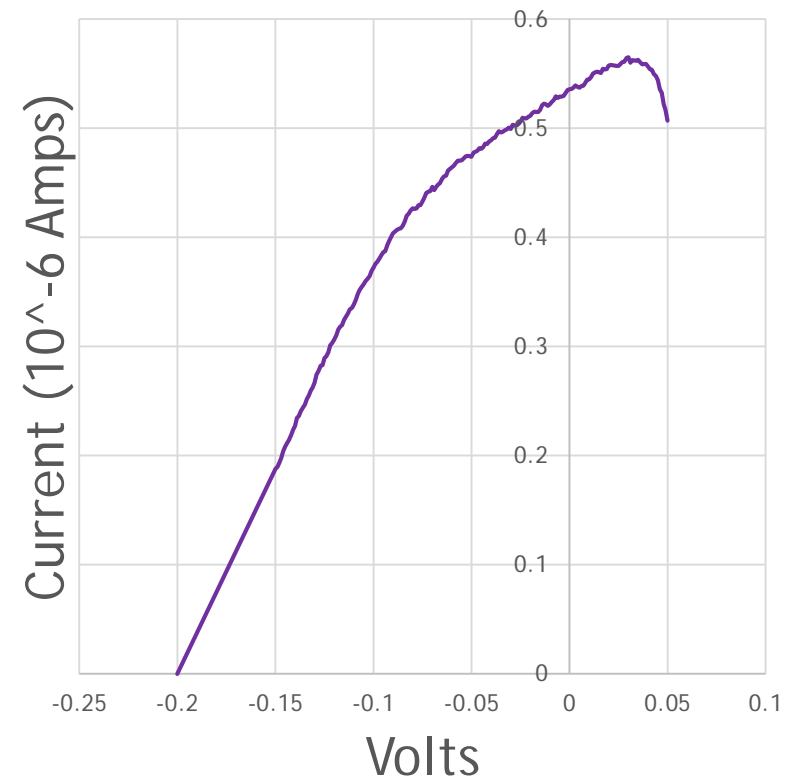
Vacuum



Argon



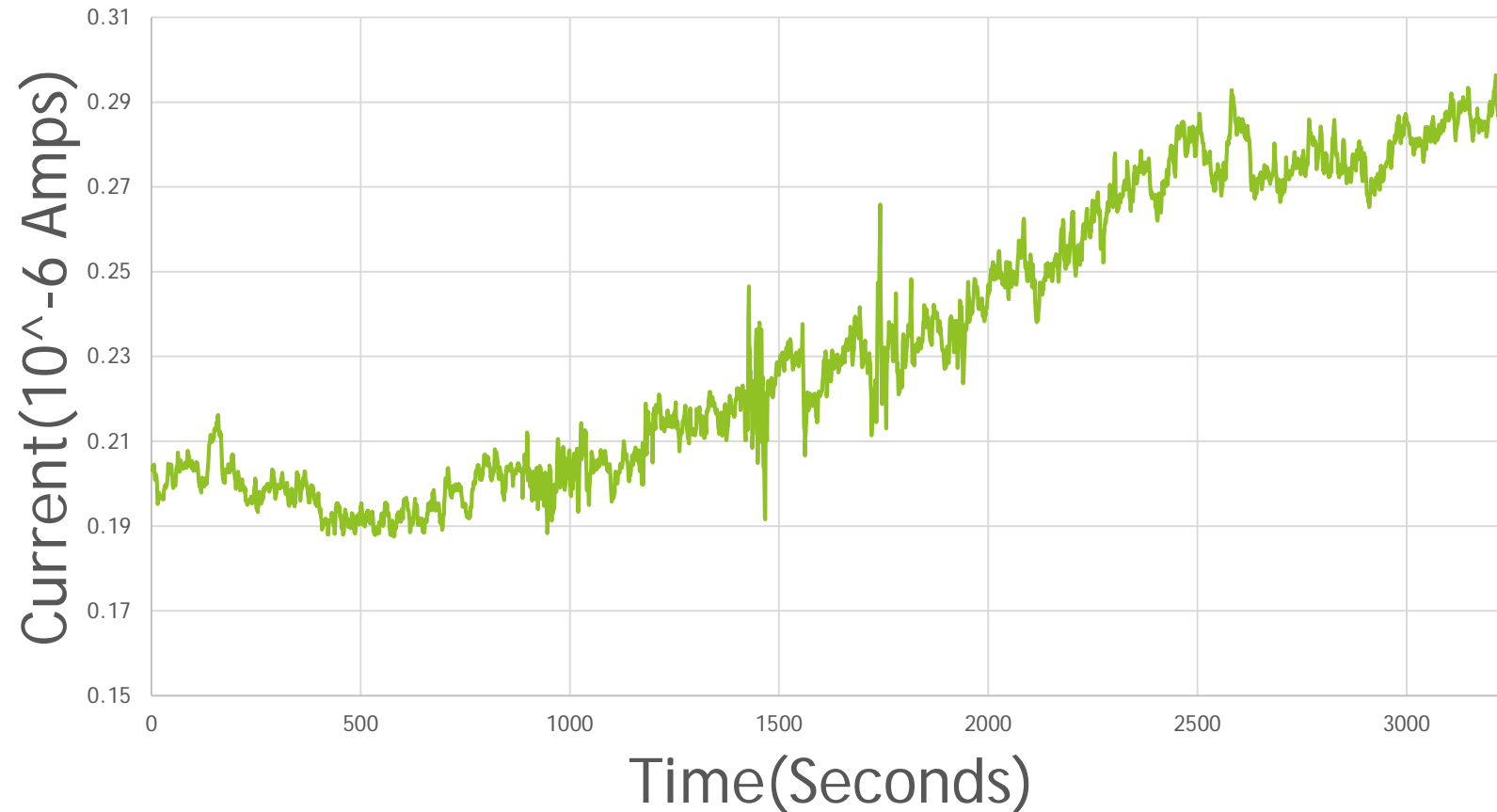
Argon + Light



Current increase with Argon + Light

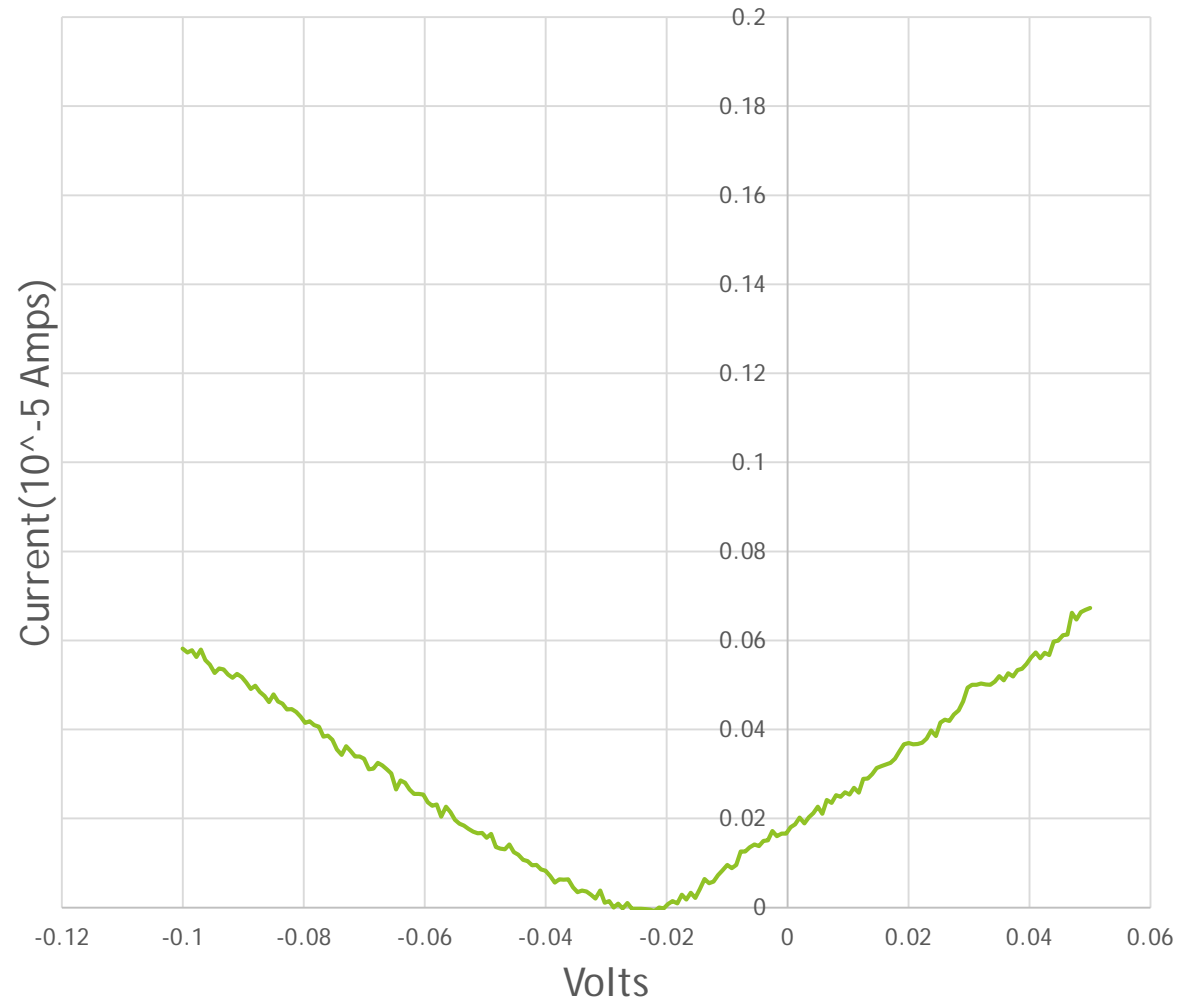
- ▶ Current continually increases over time with more exposure to light + gas

Current Value Argon + light over time

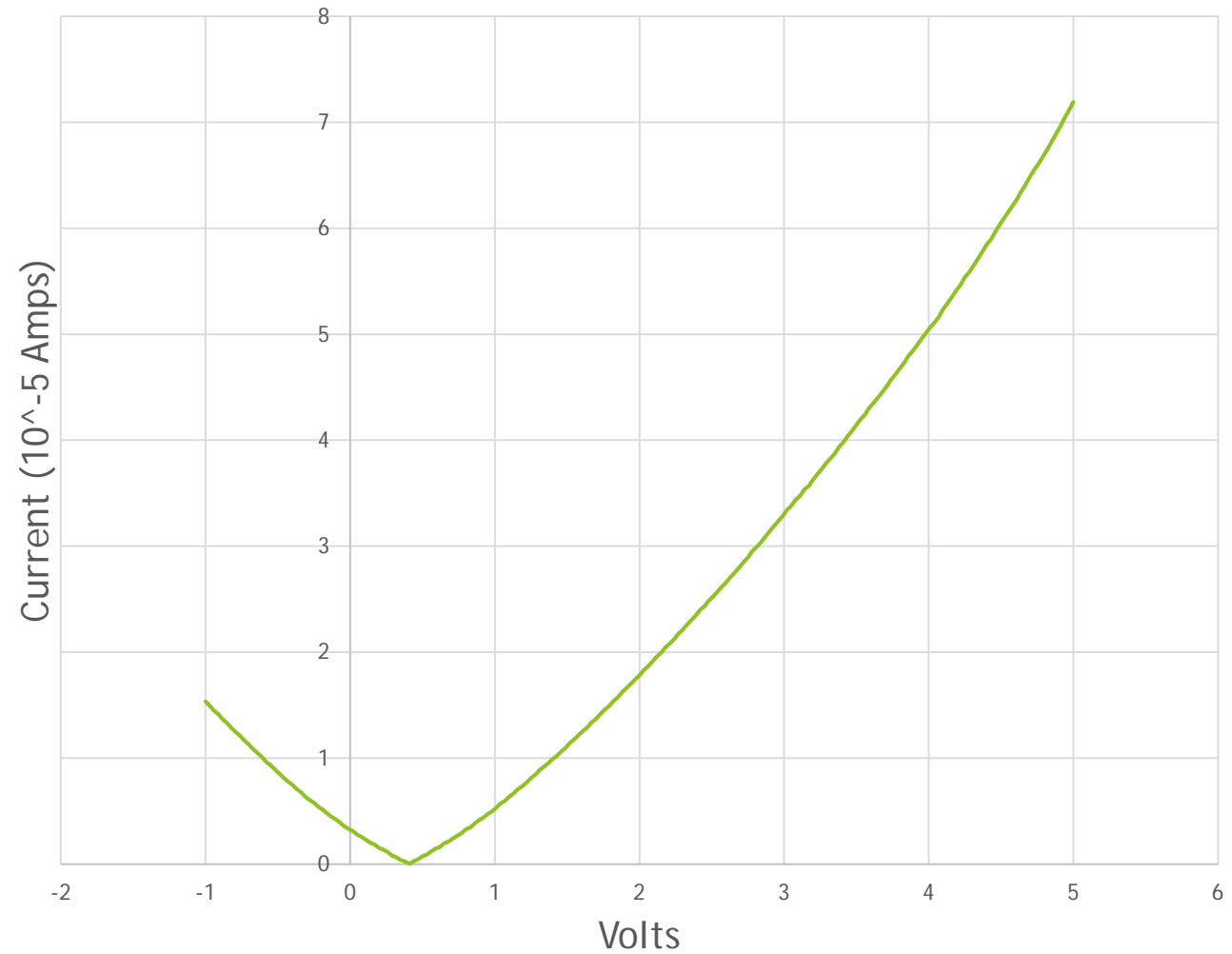


Exposure to Bias

IV Scan before applying 20V

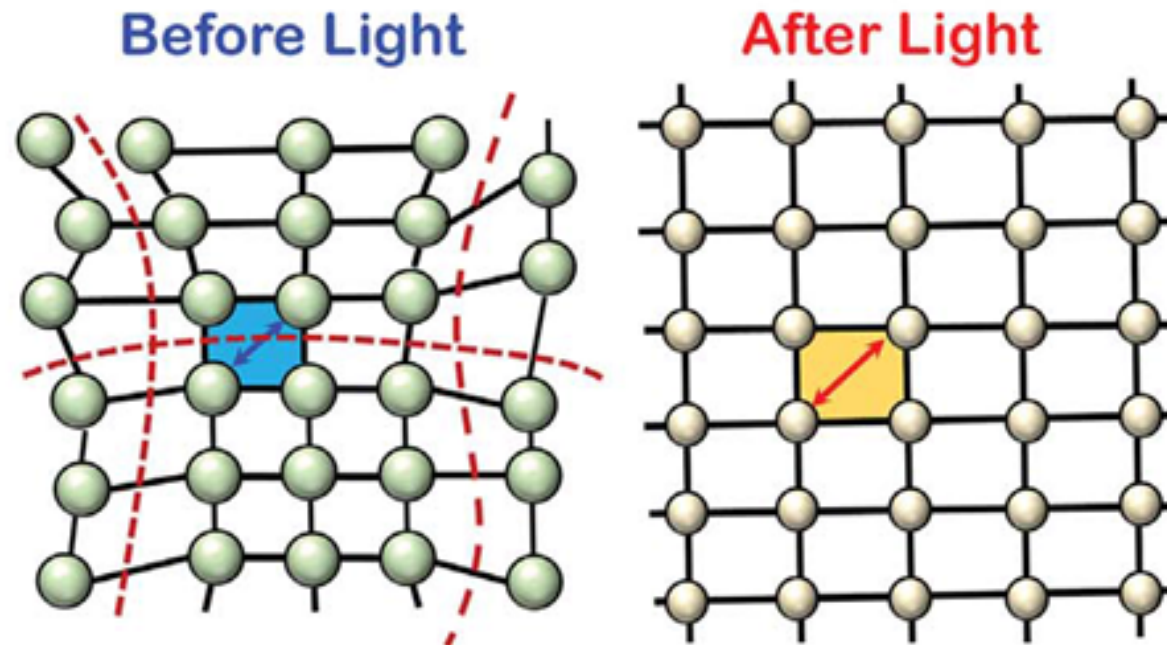


After Applying 20V



Discussion

- ▶ Reason for combination of gas + light is due to lattice expansion, affects movements of ions
- ▶ The heavier the gas, the more effect in increase in current and built in potential



Conclusions

- ▶ Wavelength for strongest signal is 730 nm
- ▶ Perovskites already have a built in potential with or without exposure to light or gases
- ▶ The lightest gas, helium, caused basically no change
- ▶ The heaviest gas, argon, created the biggest change
- ▶ Built in potential and current is affected most with combination of gas + light and exposure to bias
- ▶ Current increases over time with exposure to gas + light