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Photoelectric effect experiment

Introduction

When light hits a metal, if the light as a certain frequency, electrons can be ejected from the metal. This is because, as Einstein hypothesized and then discovered, the energy in light is quantized and carried by quanta of energy called photons. When an incoming photon strikes an electron that is part of the metal plate, the photon transfers its energy to the electron. If the energy of the photon was great enough, the electron can gain enough energy to escape from the metal. The threshold energy for electrons to escape from the surface from a given material is called the work function of the material. If two plates are set up such that one has light shown on it, and the other, obscured from that light, is positioned in a direct line to the other metal plate, ejected electrons from the first plate will reach the second plate. If the two plates are connected electrically, a small current can be carried by the ejection of electrons from one plate to the other. If a voltage is applied between the two plates, it is possible to limit the amount of electrons that make up the current flowing, and even stop any ejected electron from reaching the other plate. The applied voltage at which this occurs is called the stopping voltage.

Setup

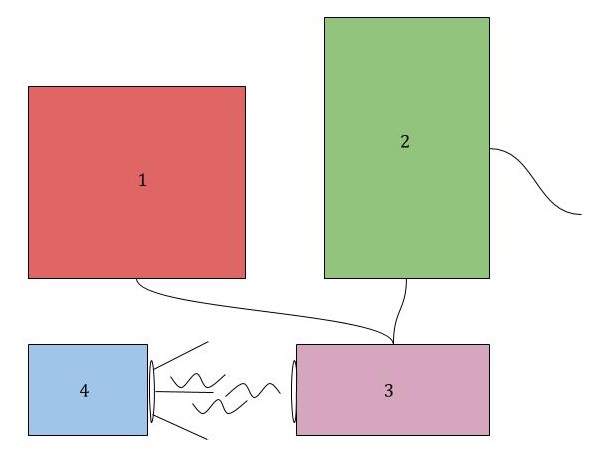


Figure 1: A depiction of the experimental setup. (1) Power supply controlling the voltage between the plates in (3). (2) A picoammeter reading the current created by ejected electrons, connected to a laptop (not shown) that stores the data. (3) The phototube that houses the two plates and has attached to it several filters for filtering incoming light. (4) A mercury lamp that provides the light to eject electrons from (3).

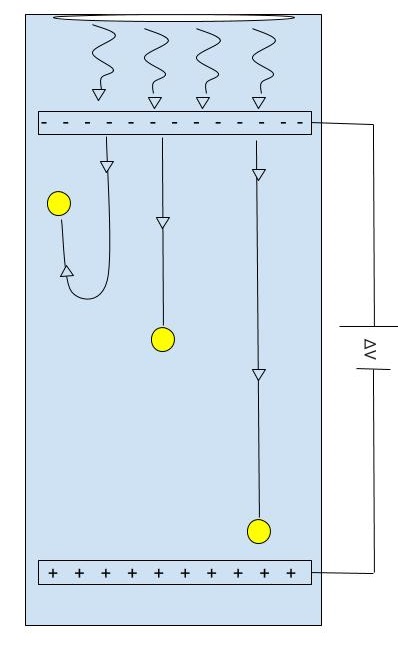
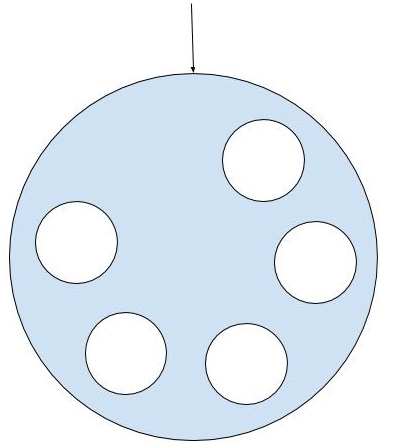
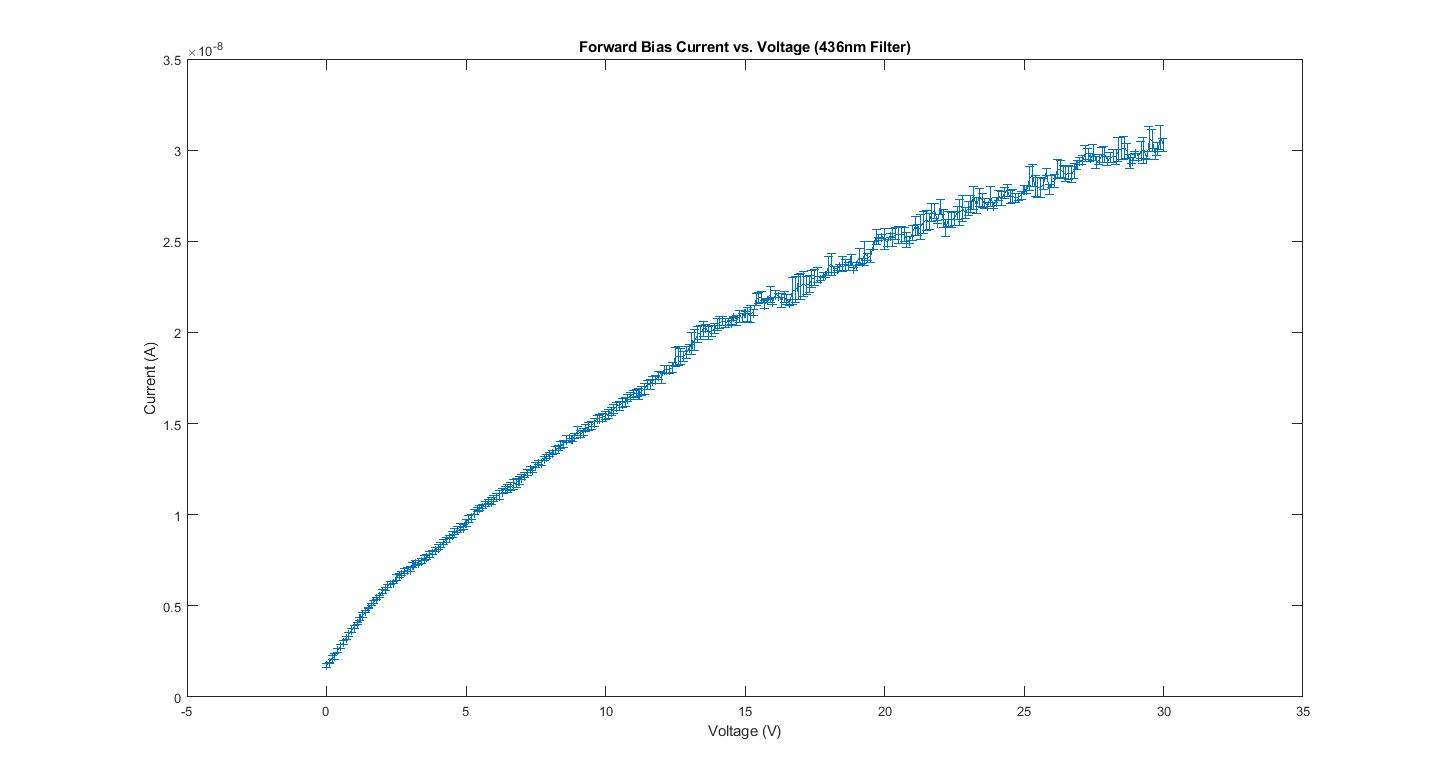
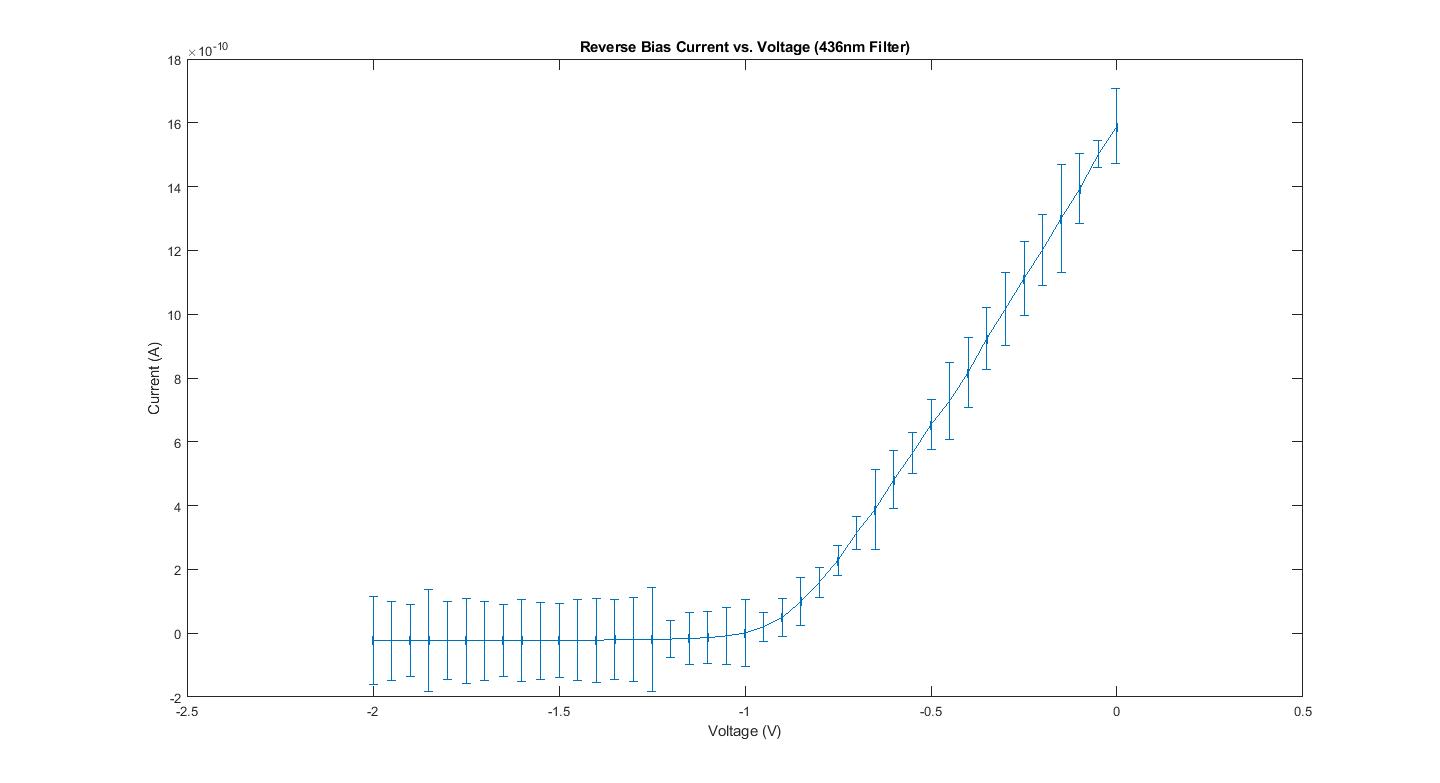
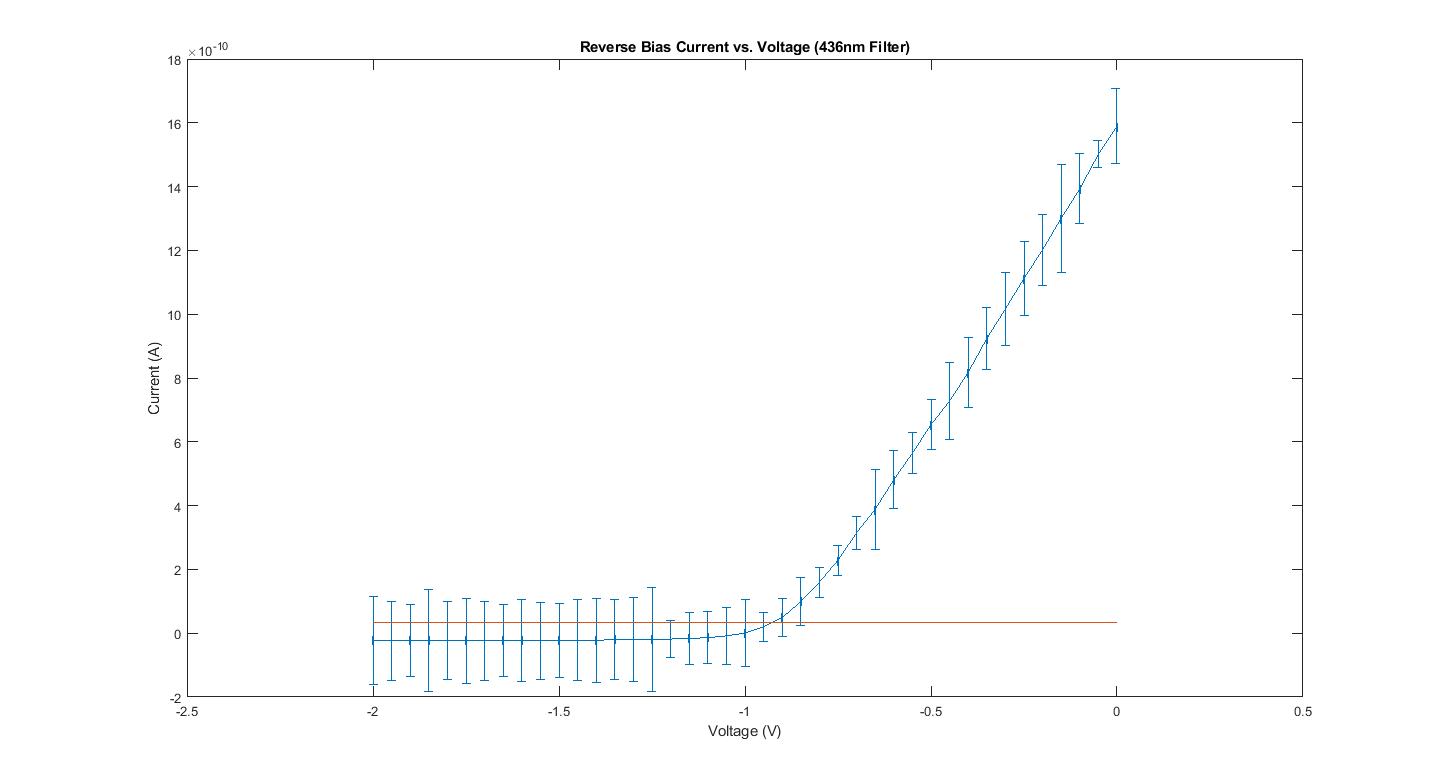
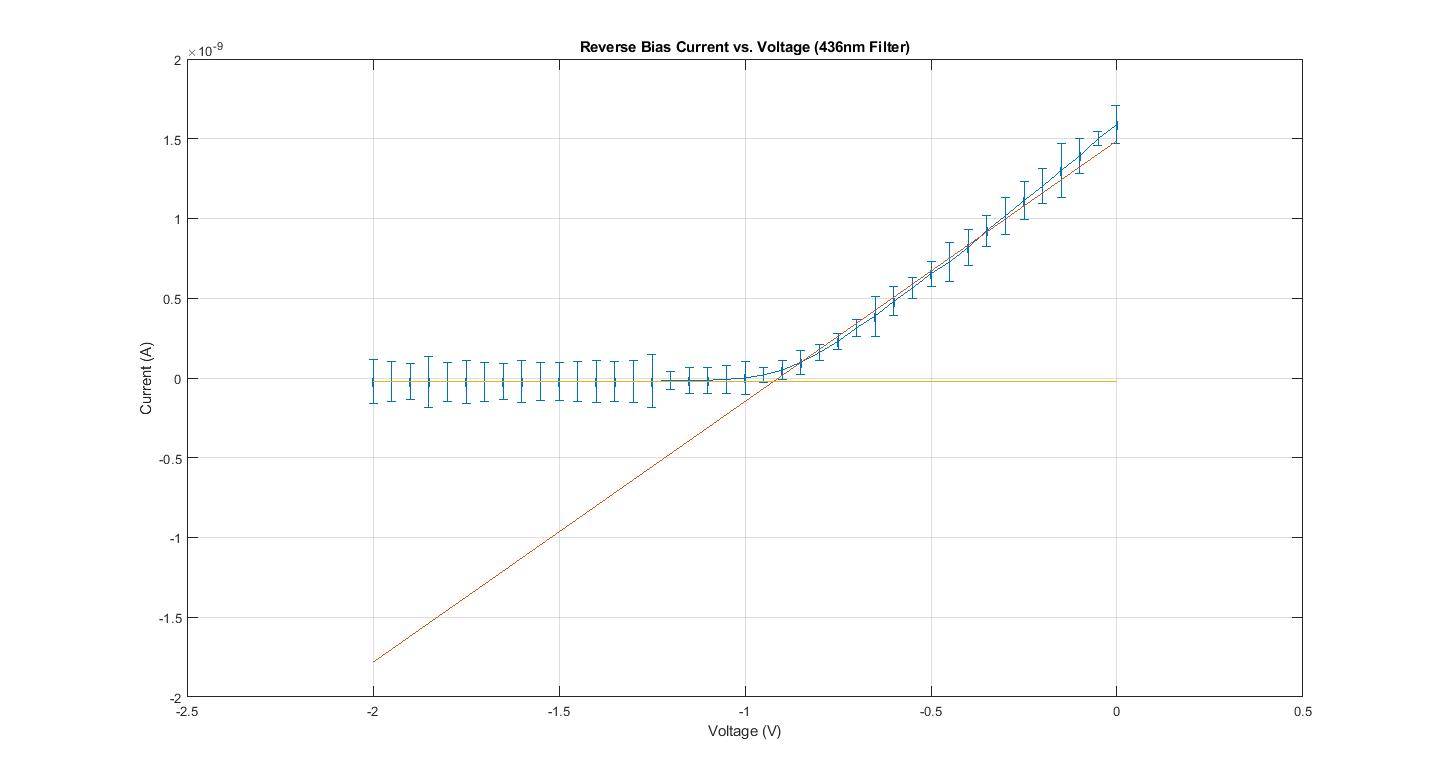
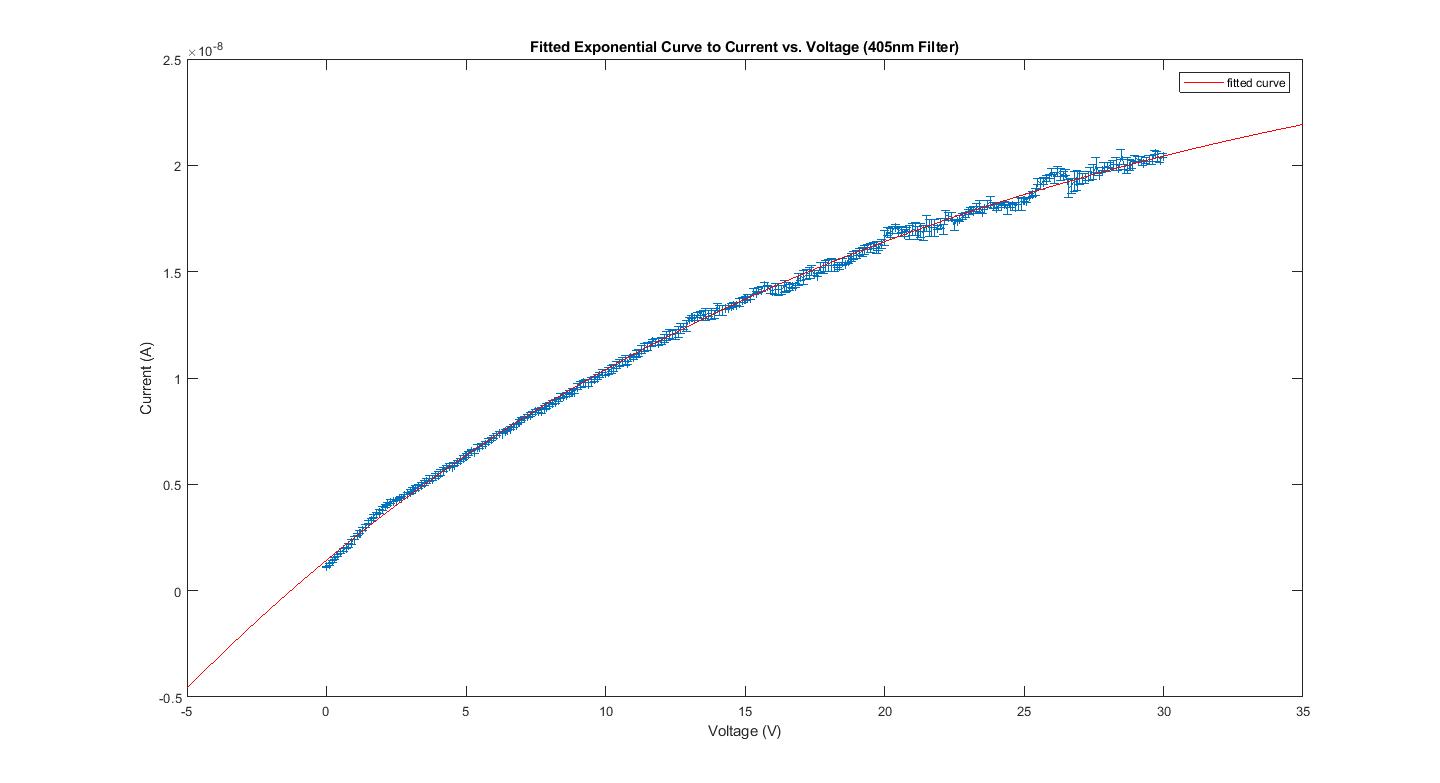
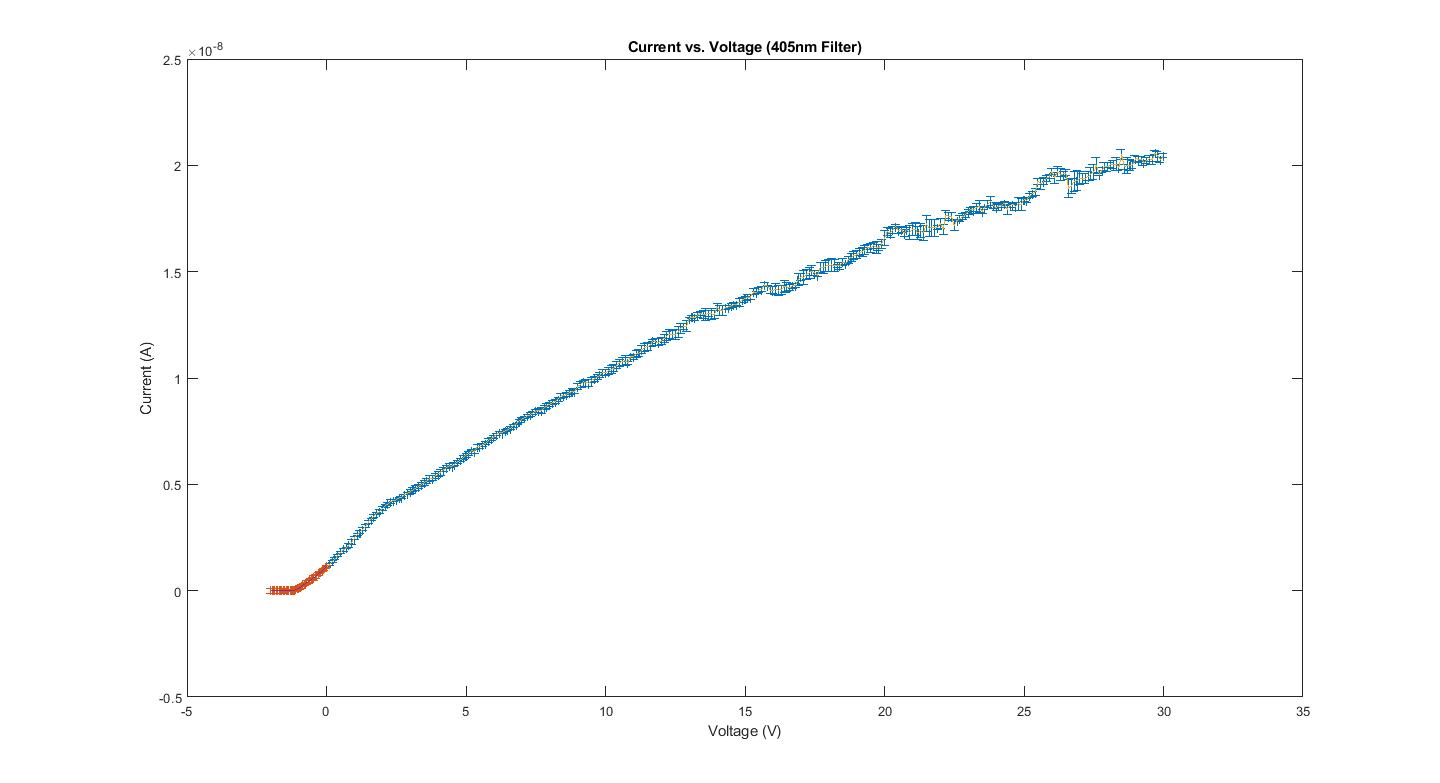
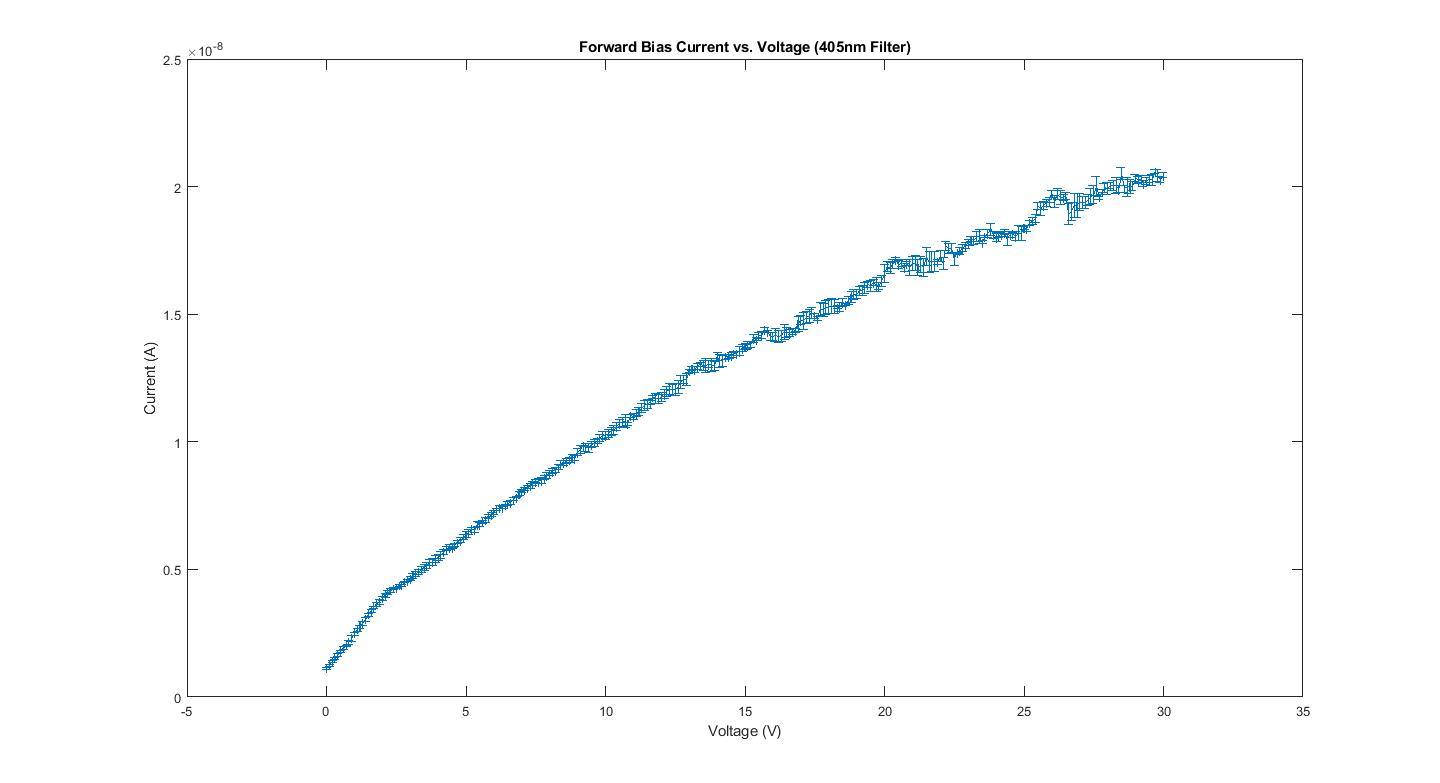
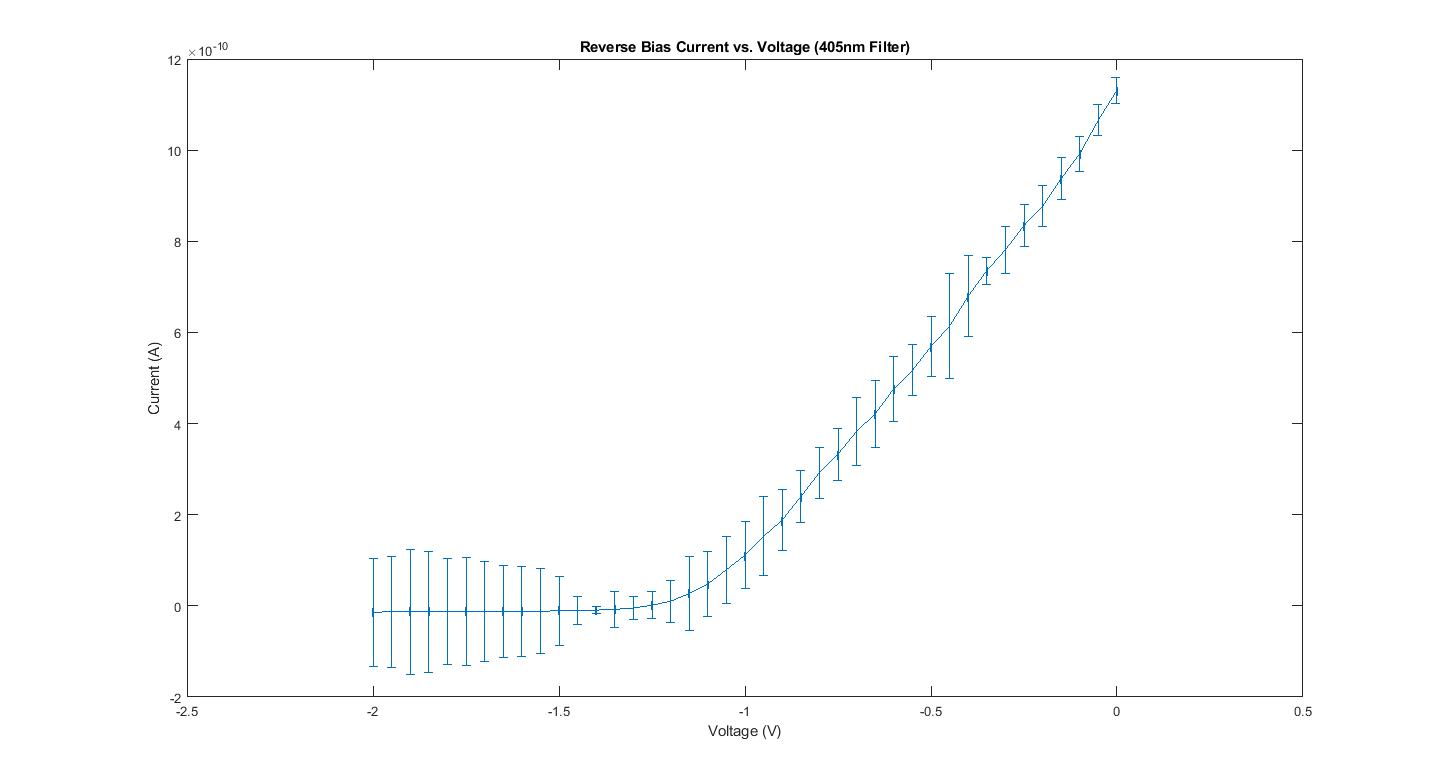
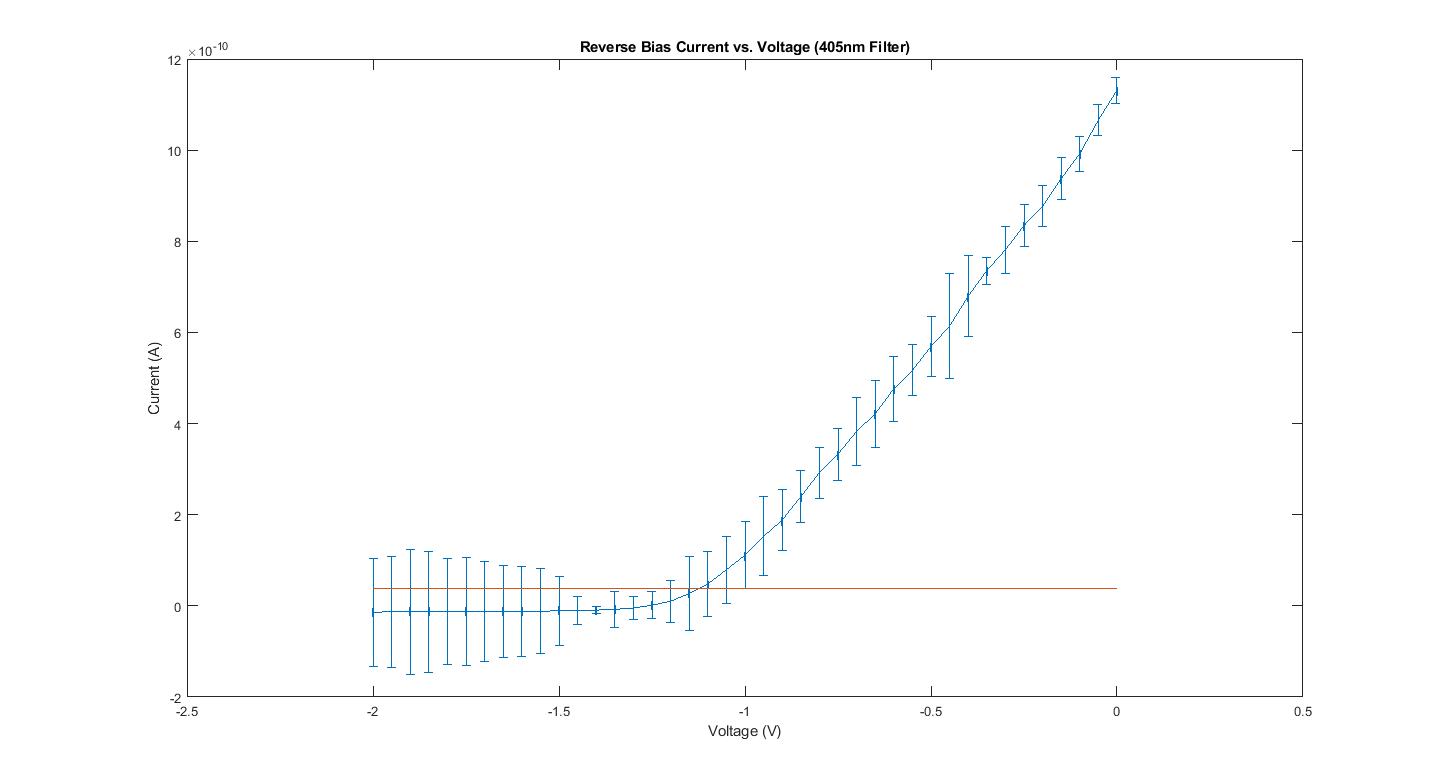
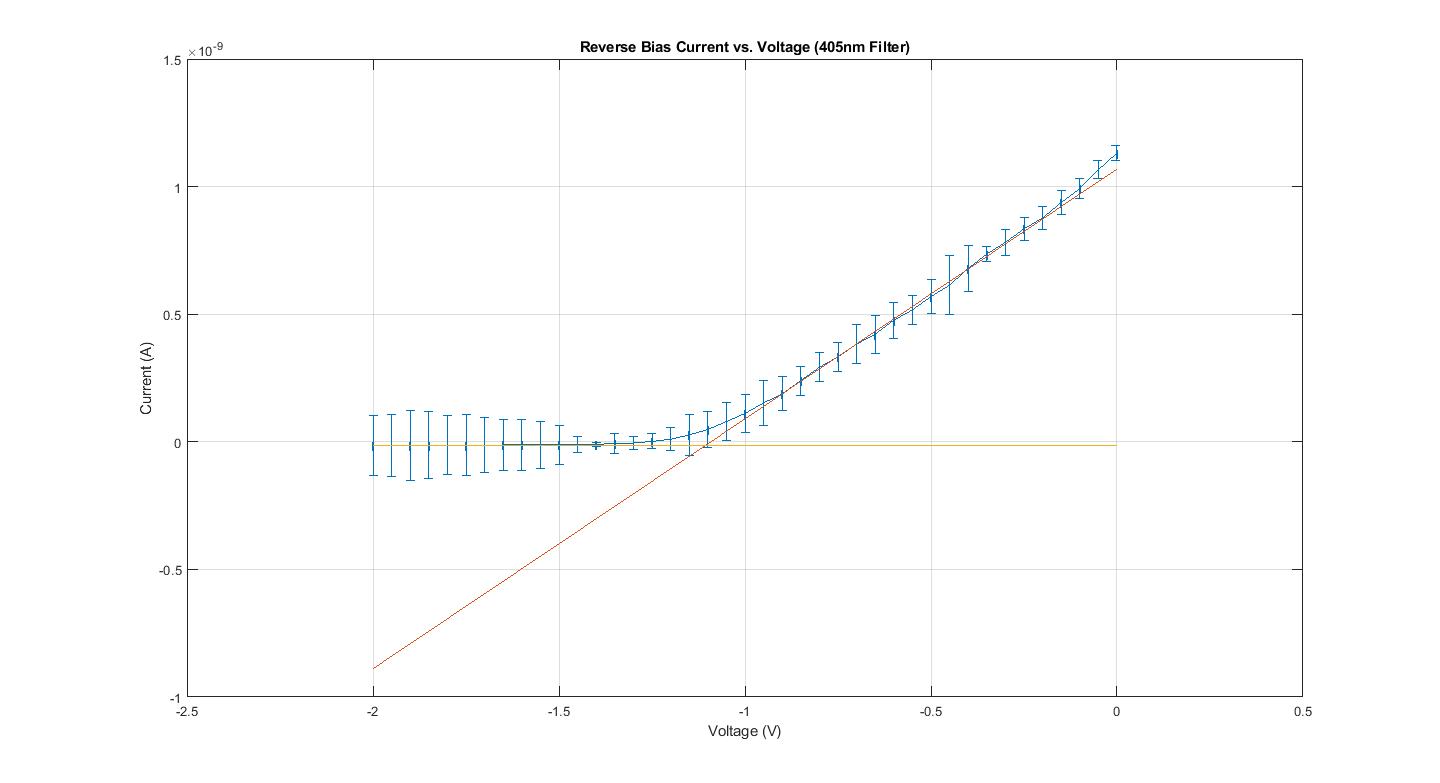
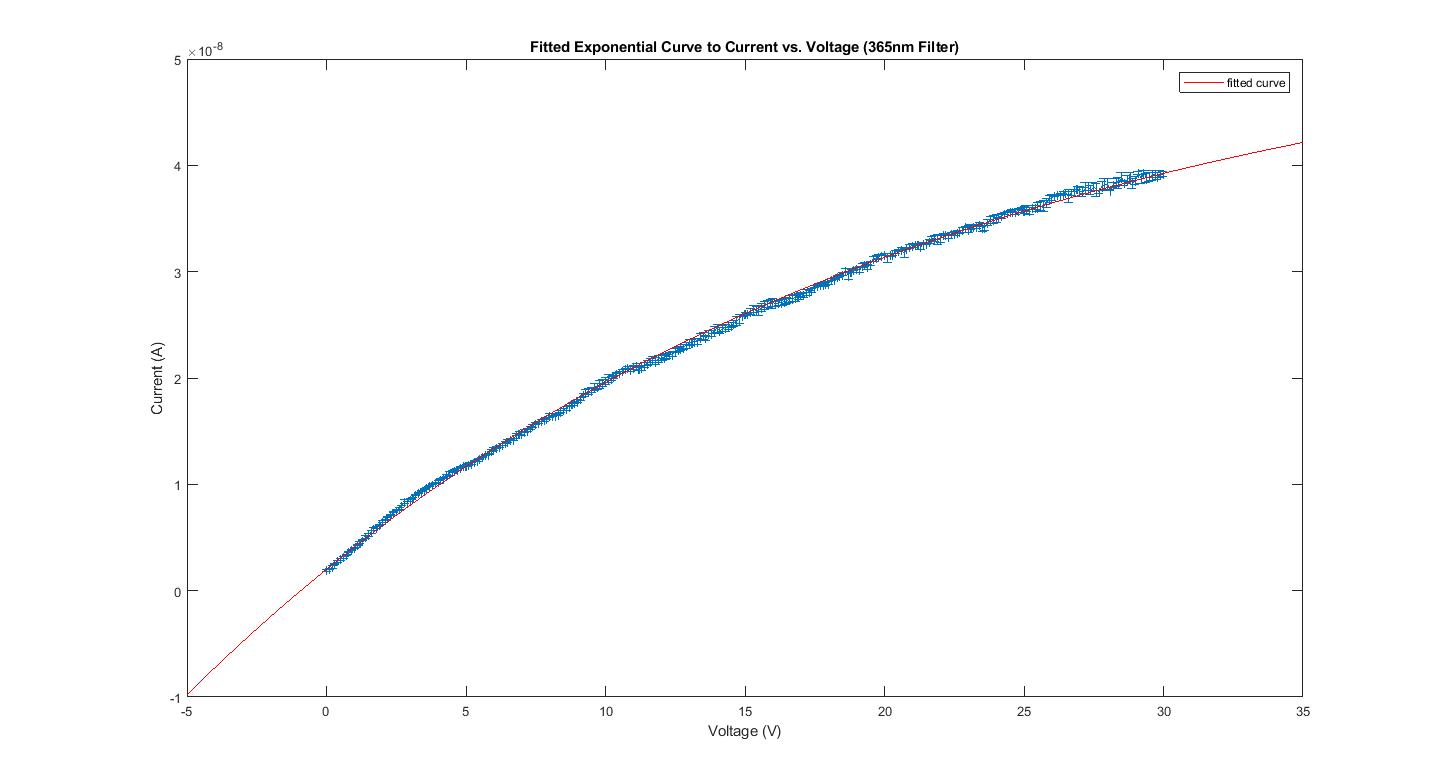
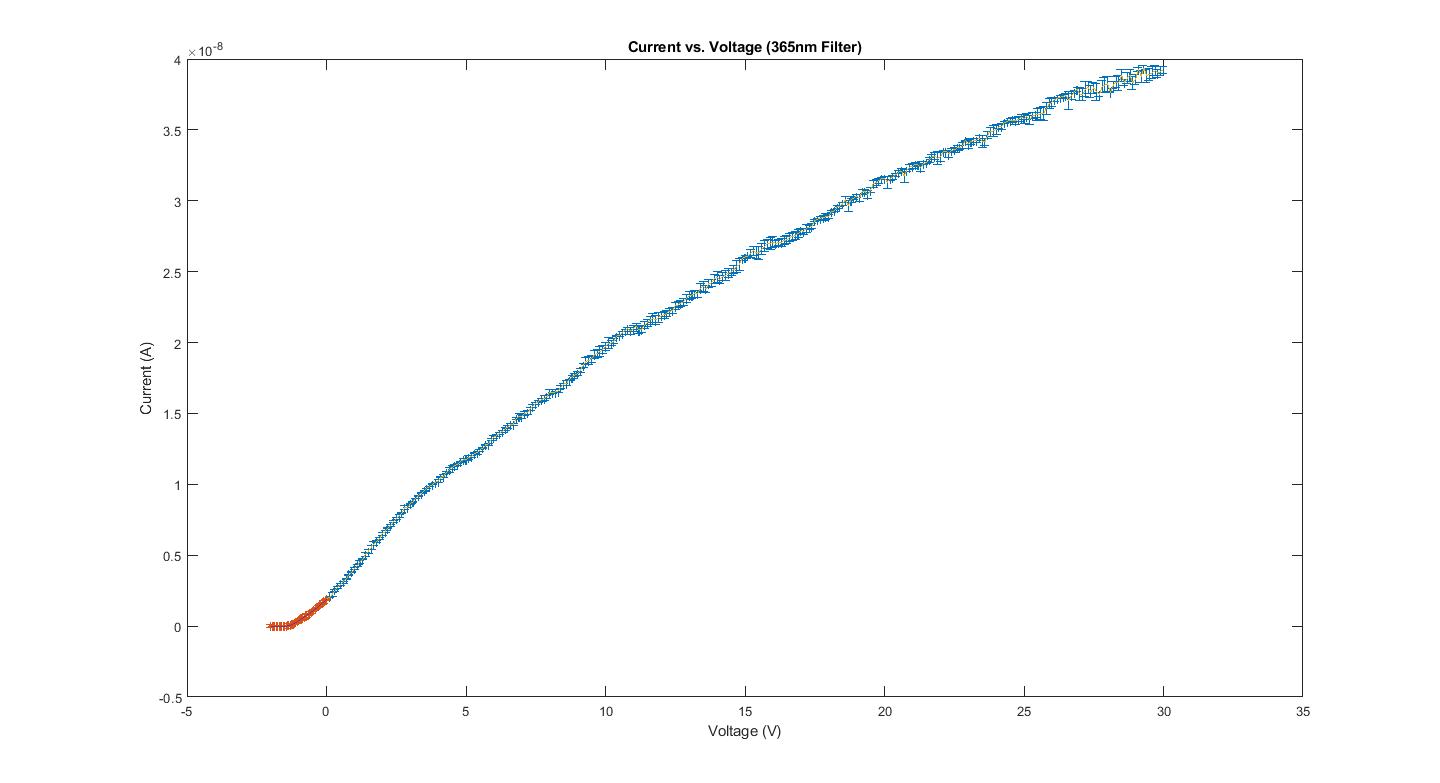
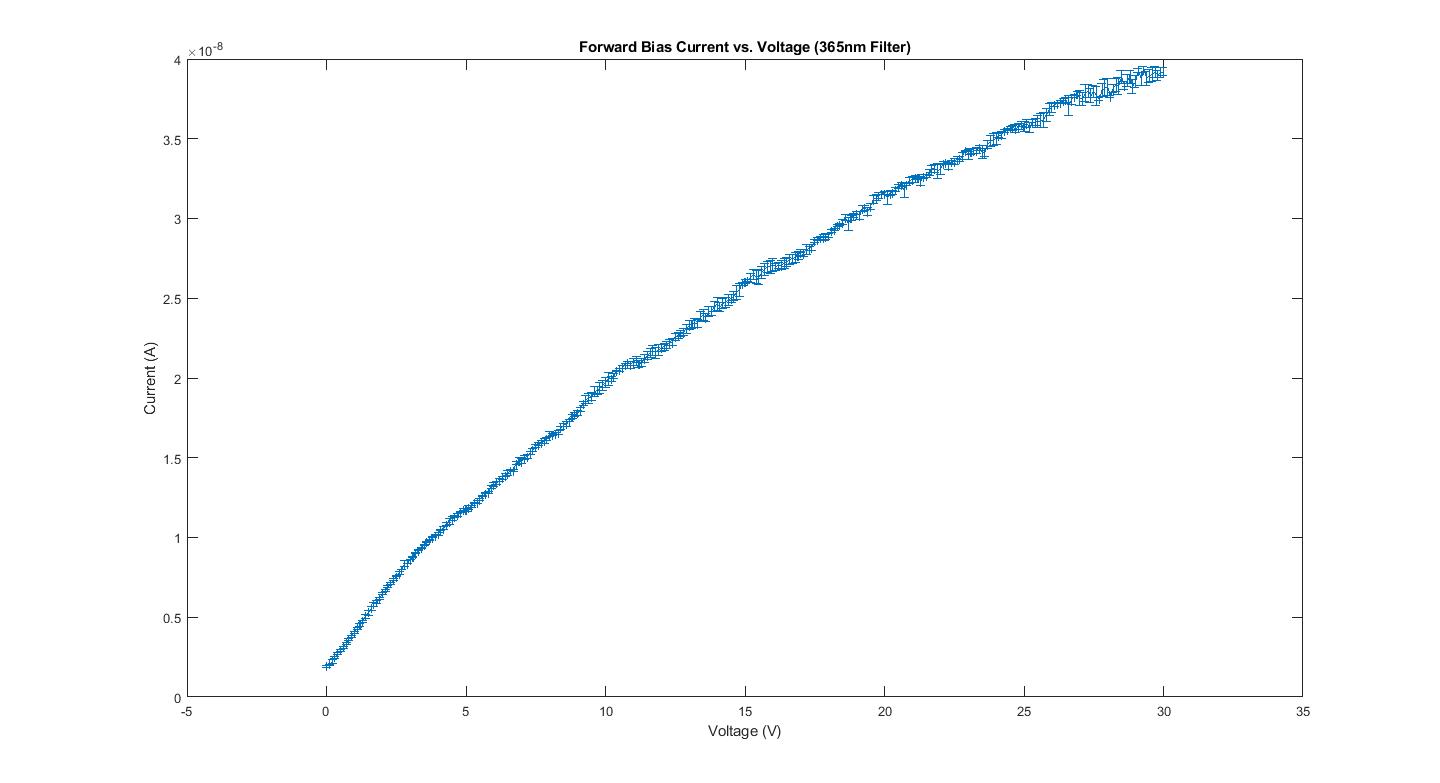
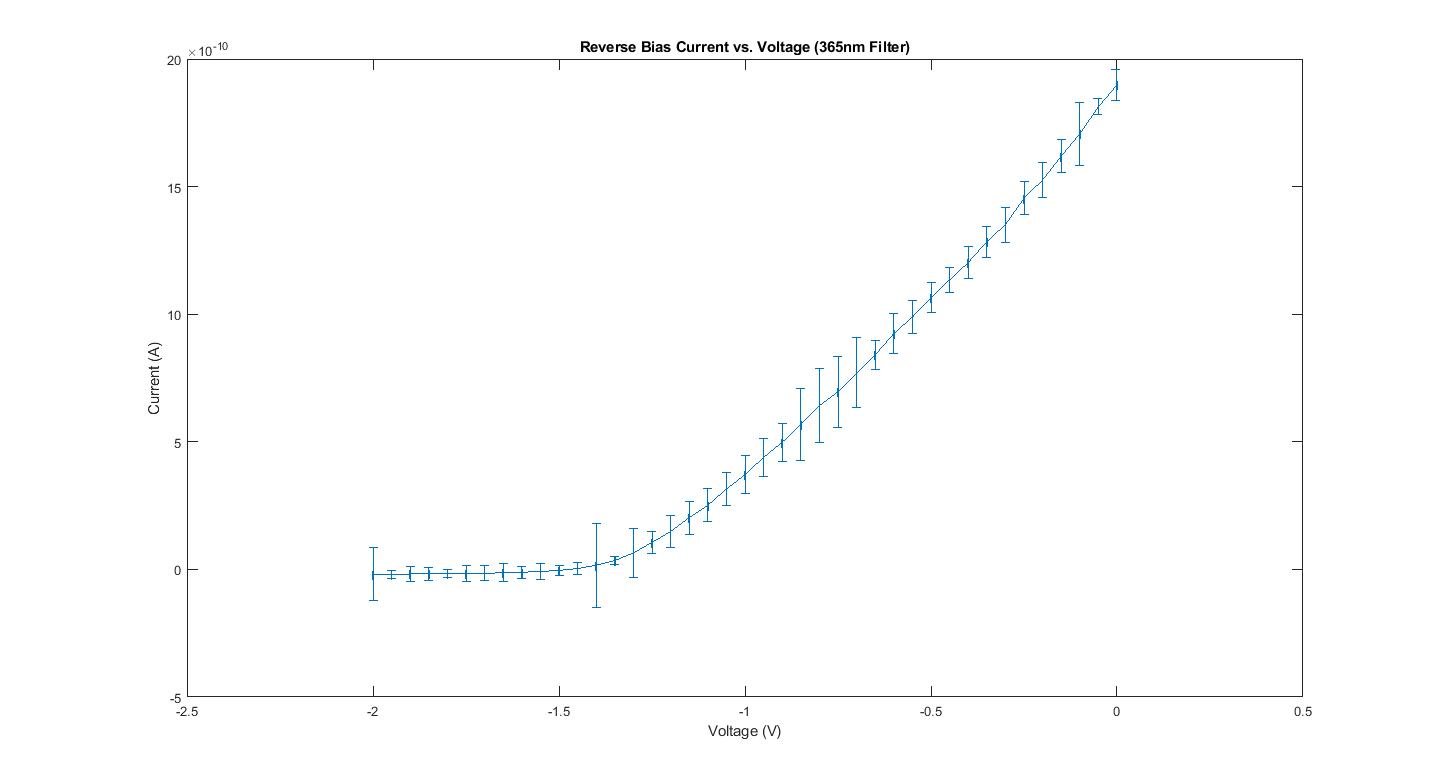
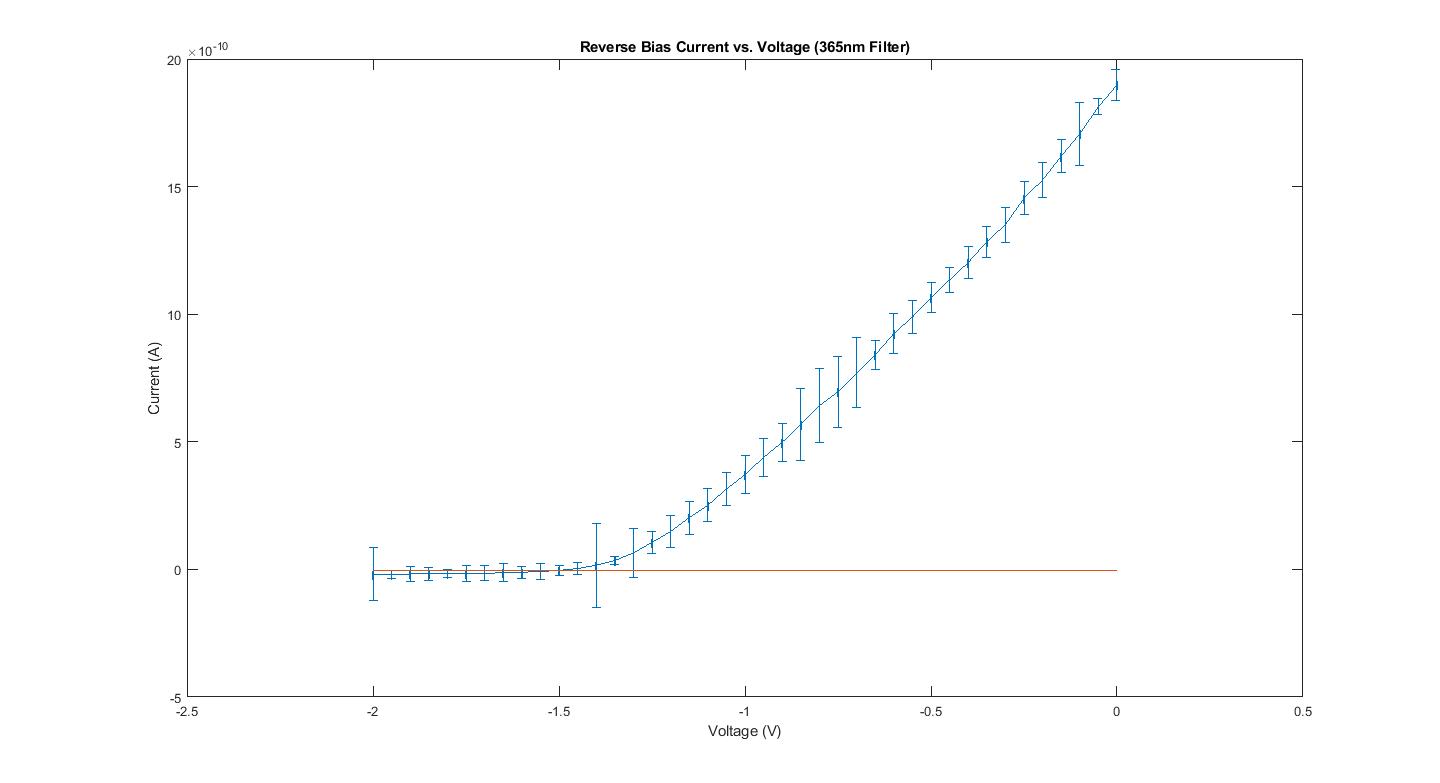
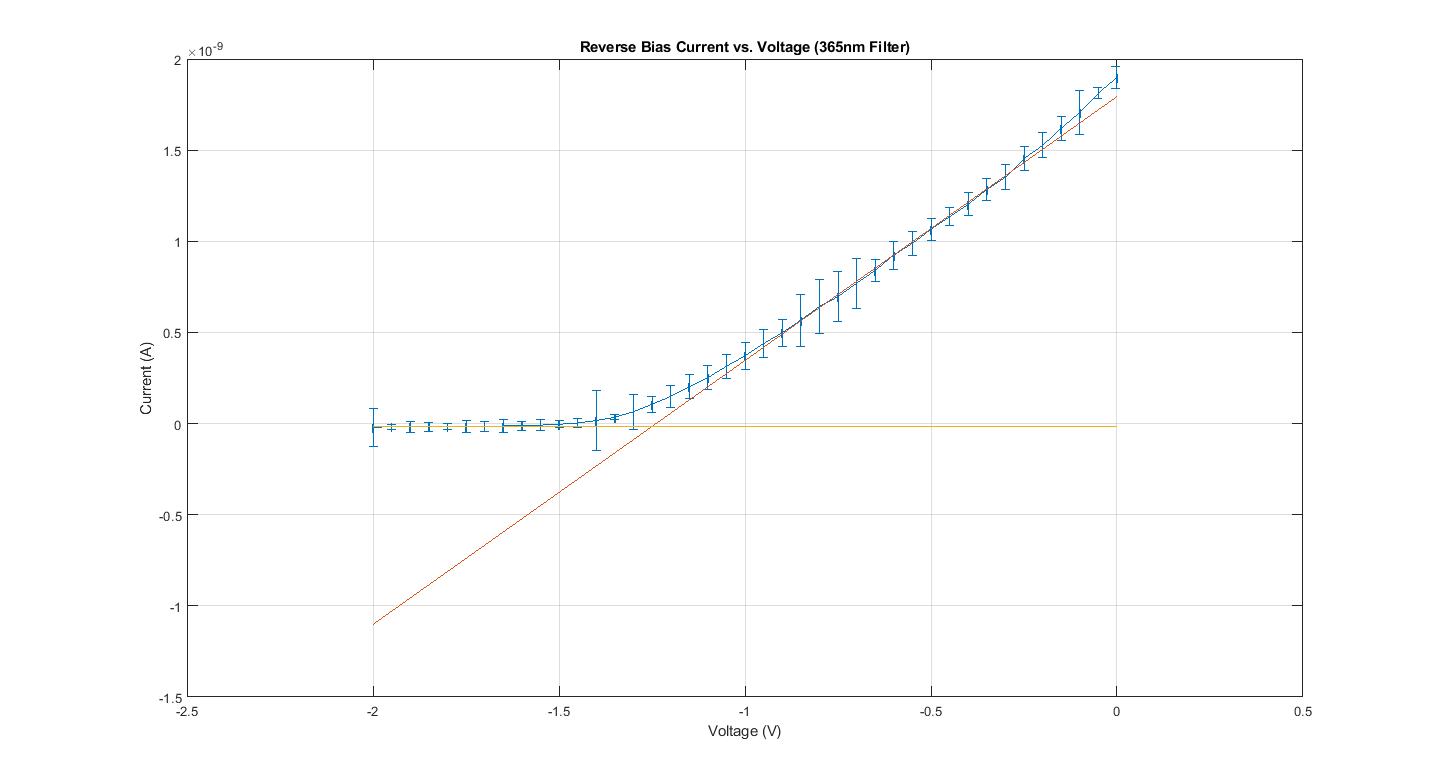
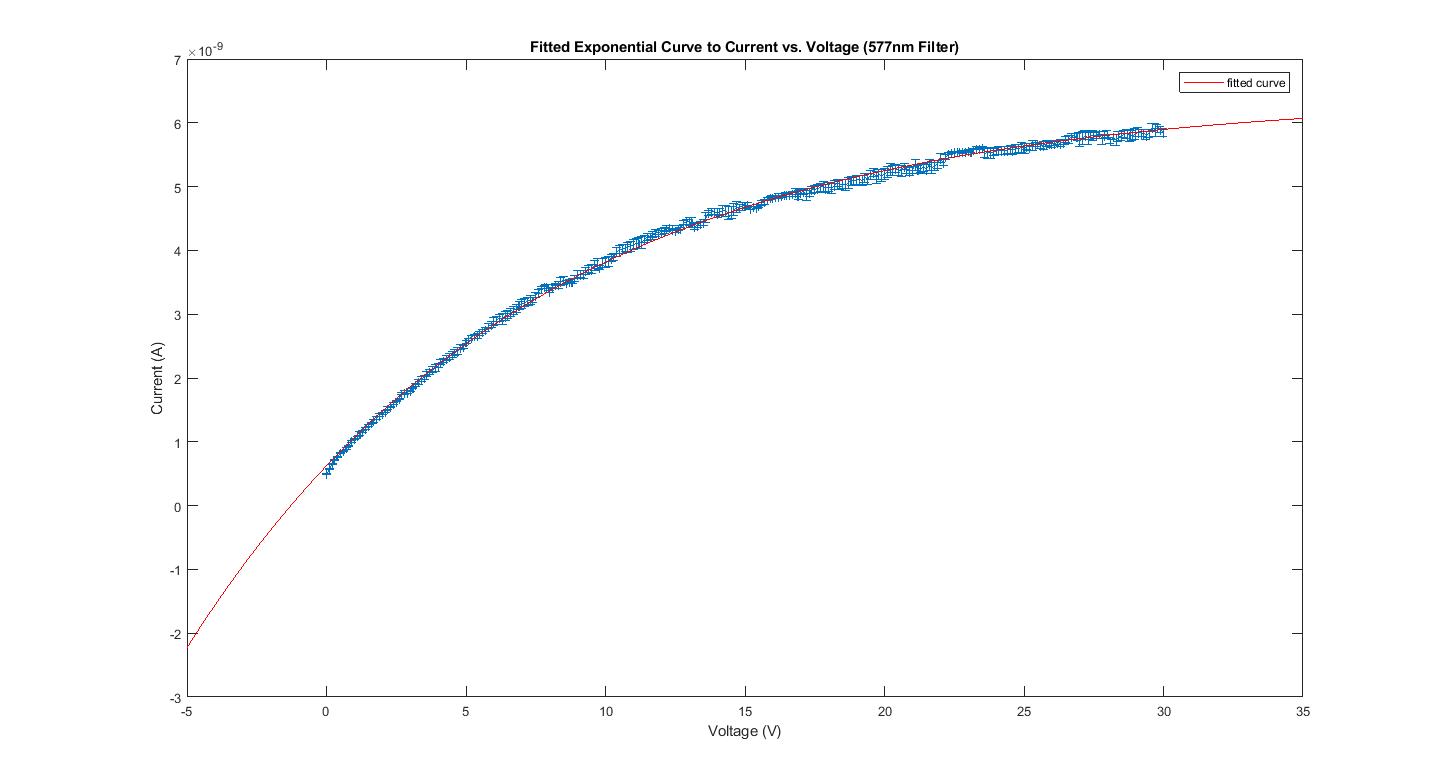
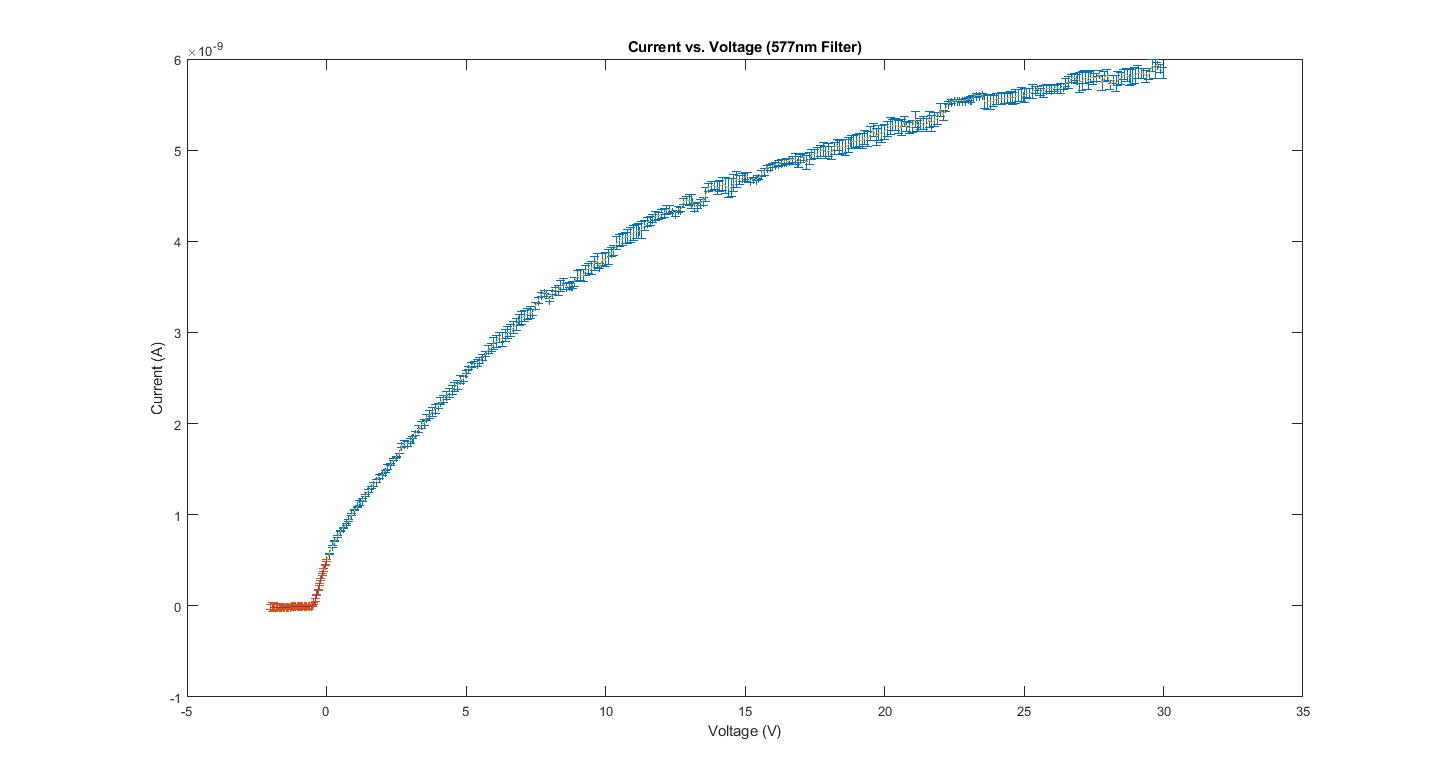
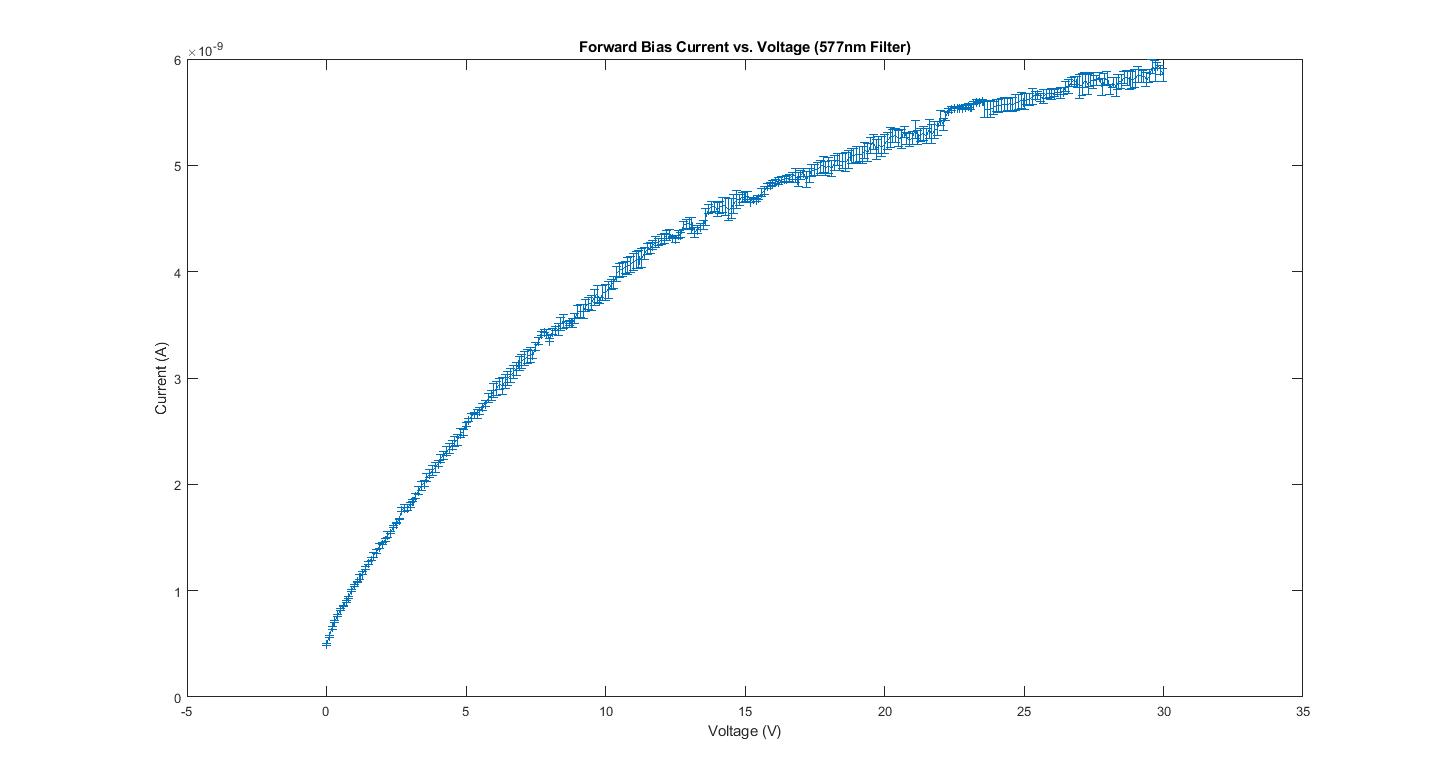
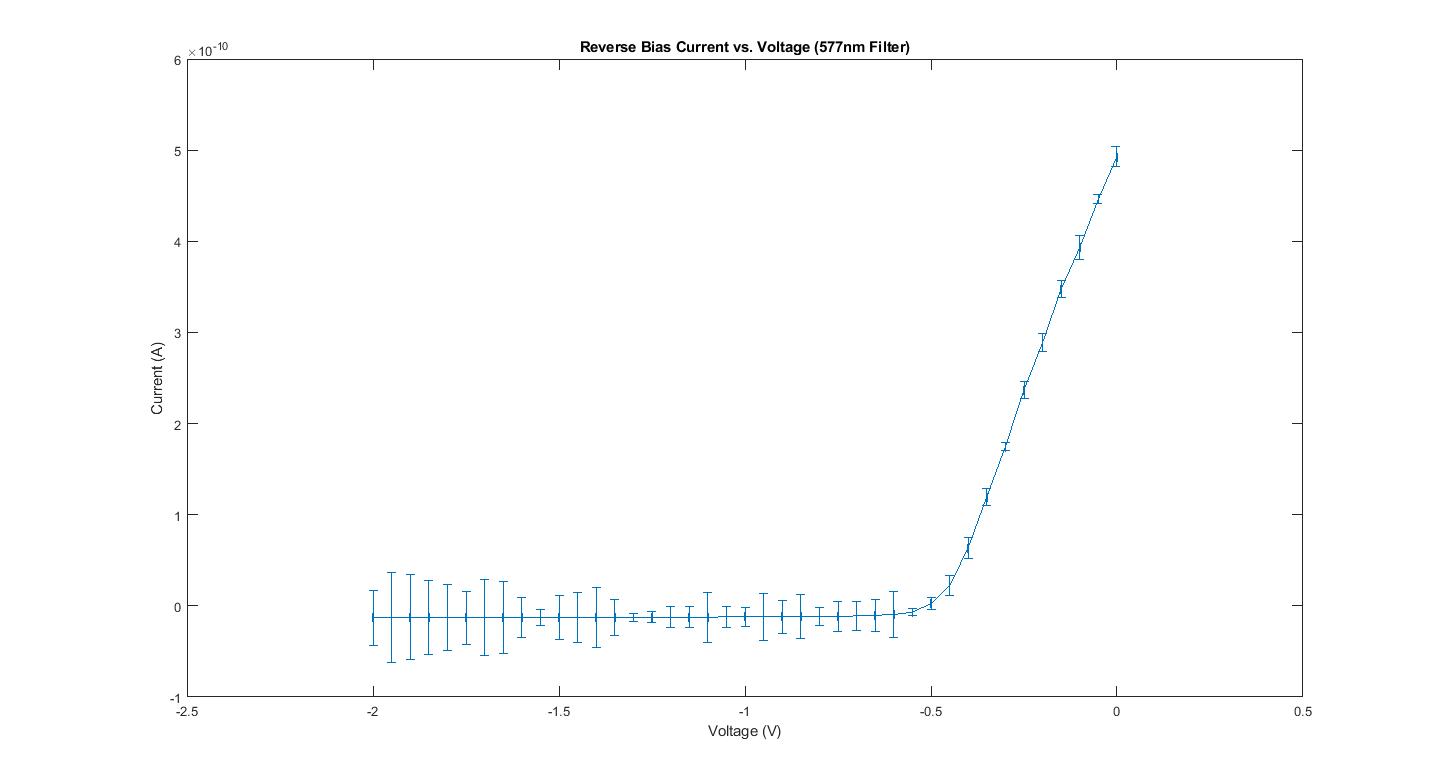
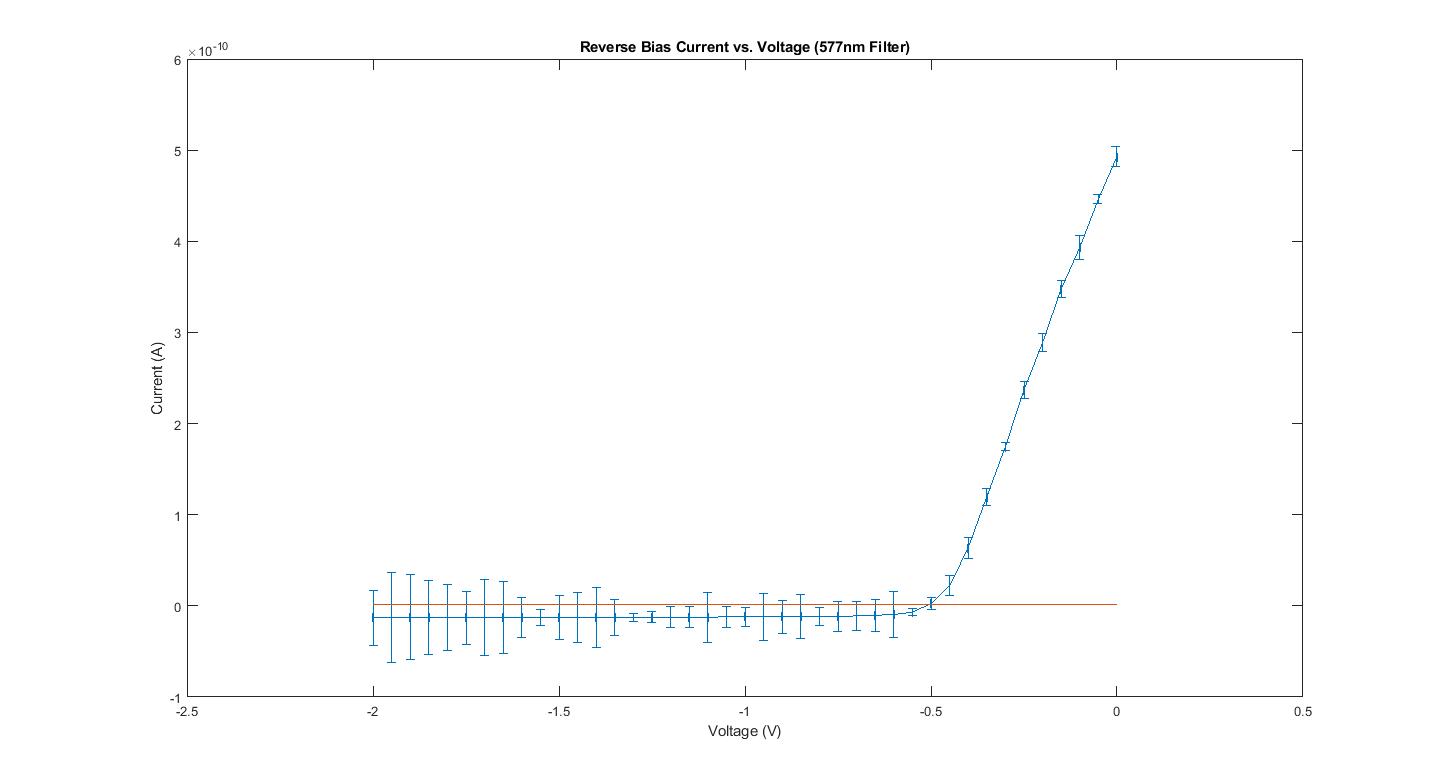
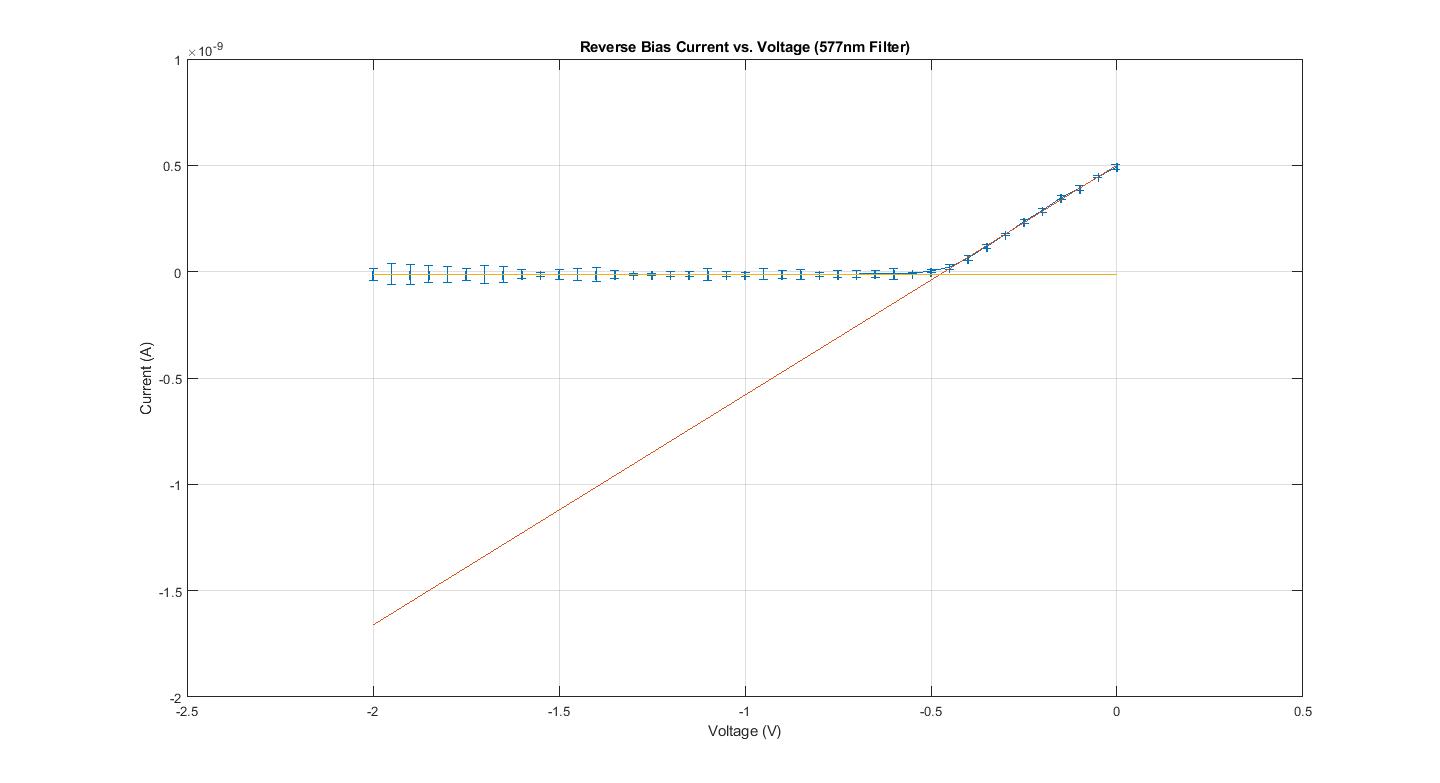
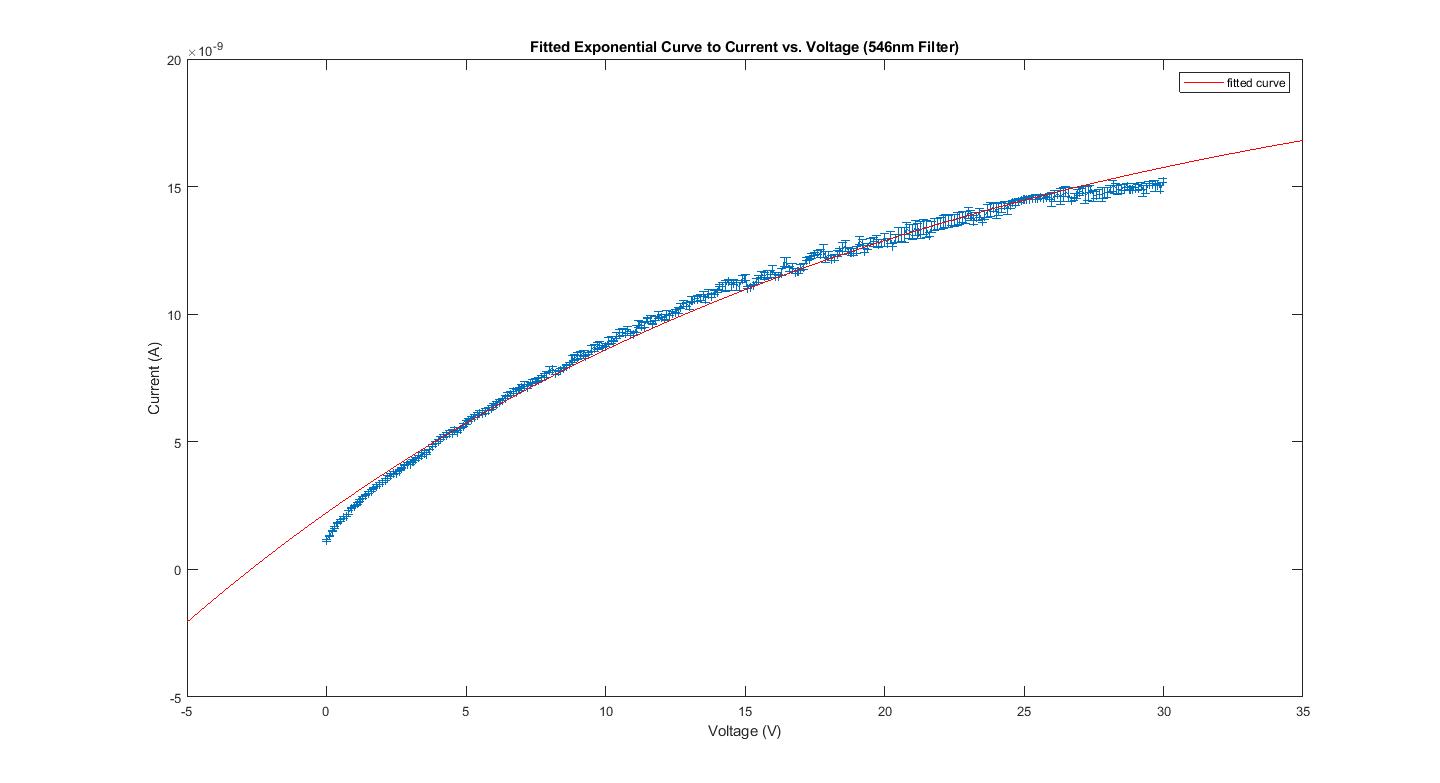
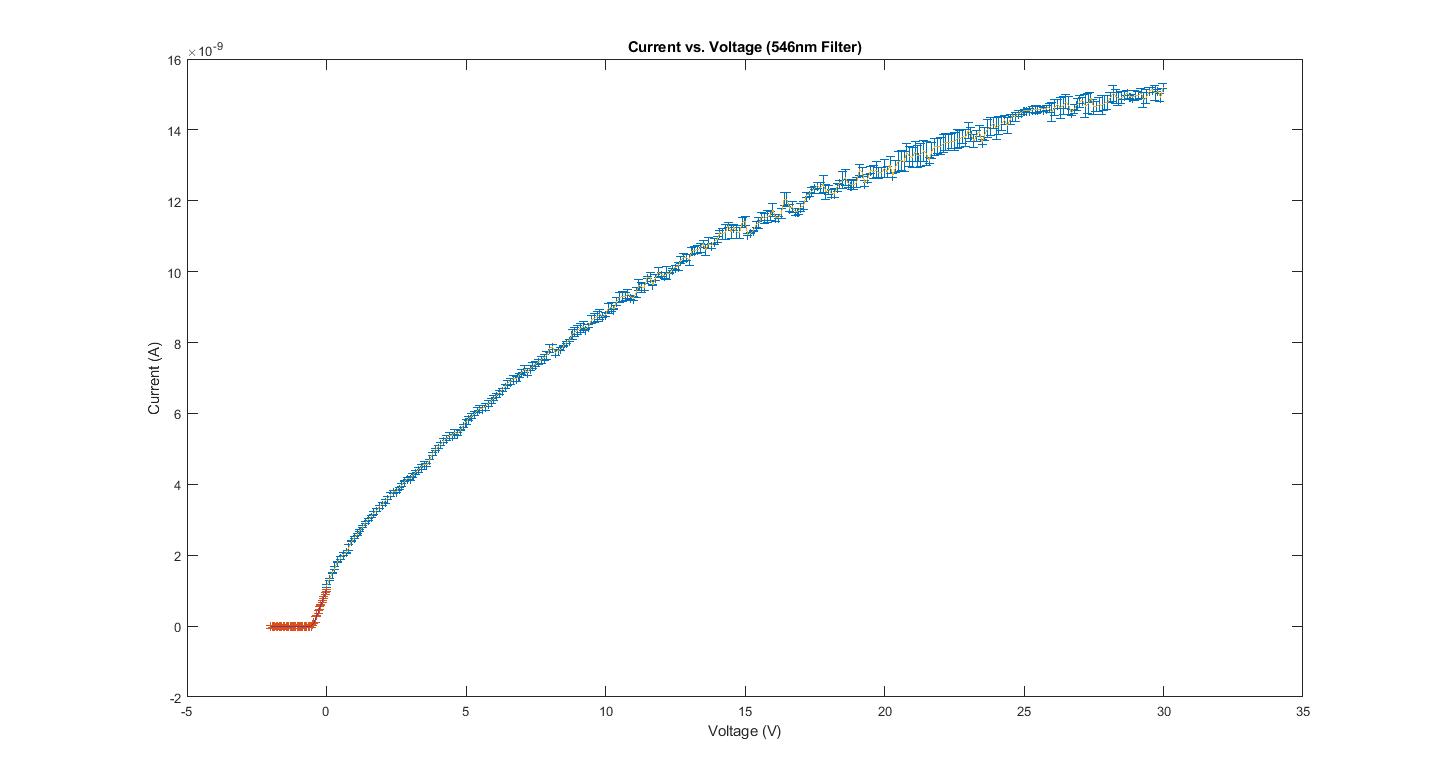
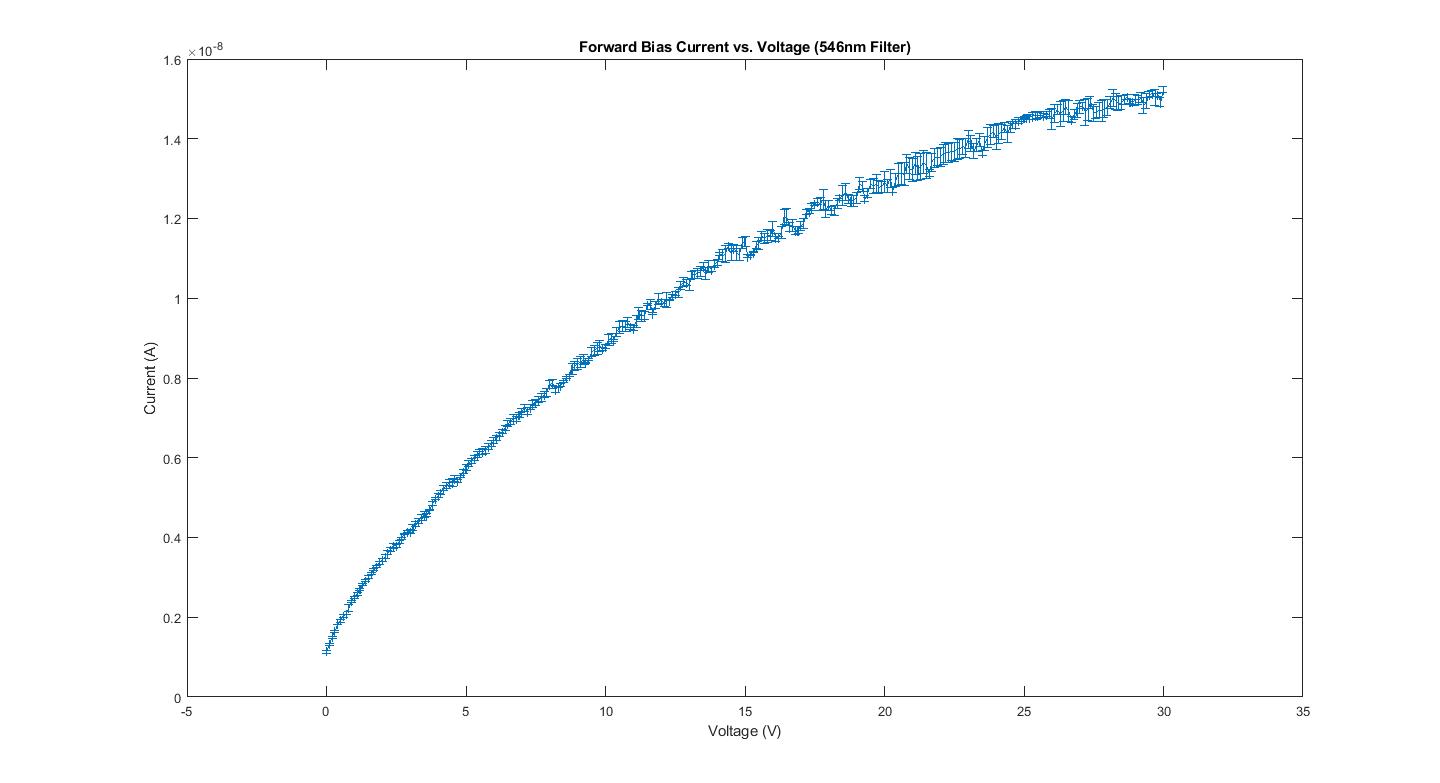
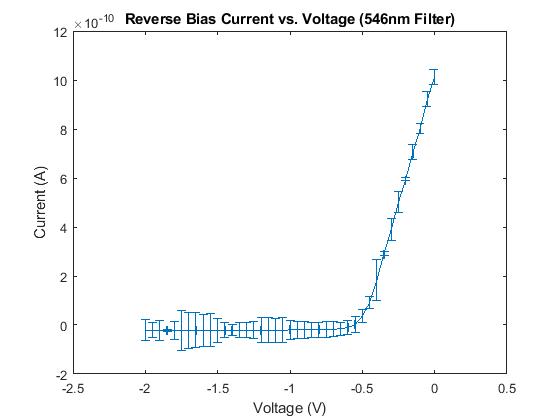
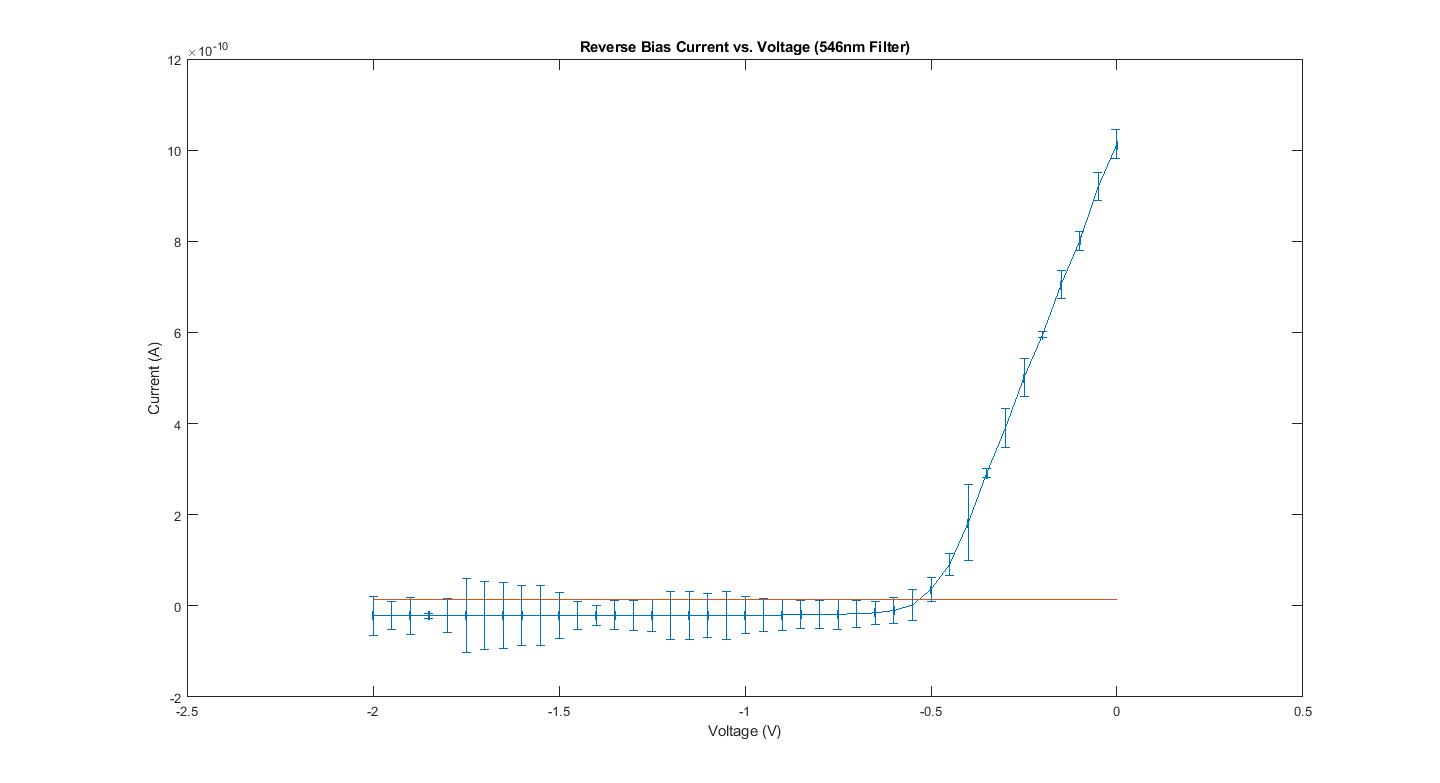
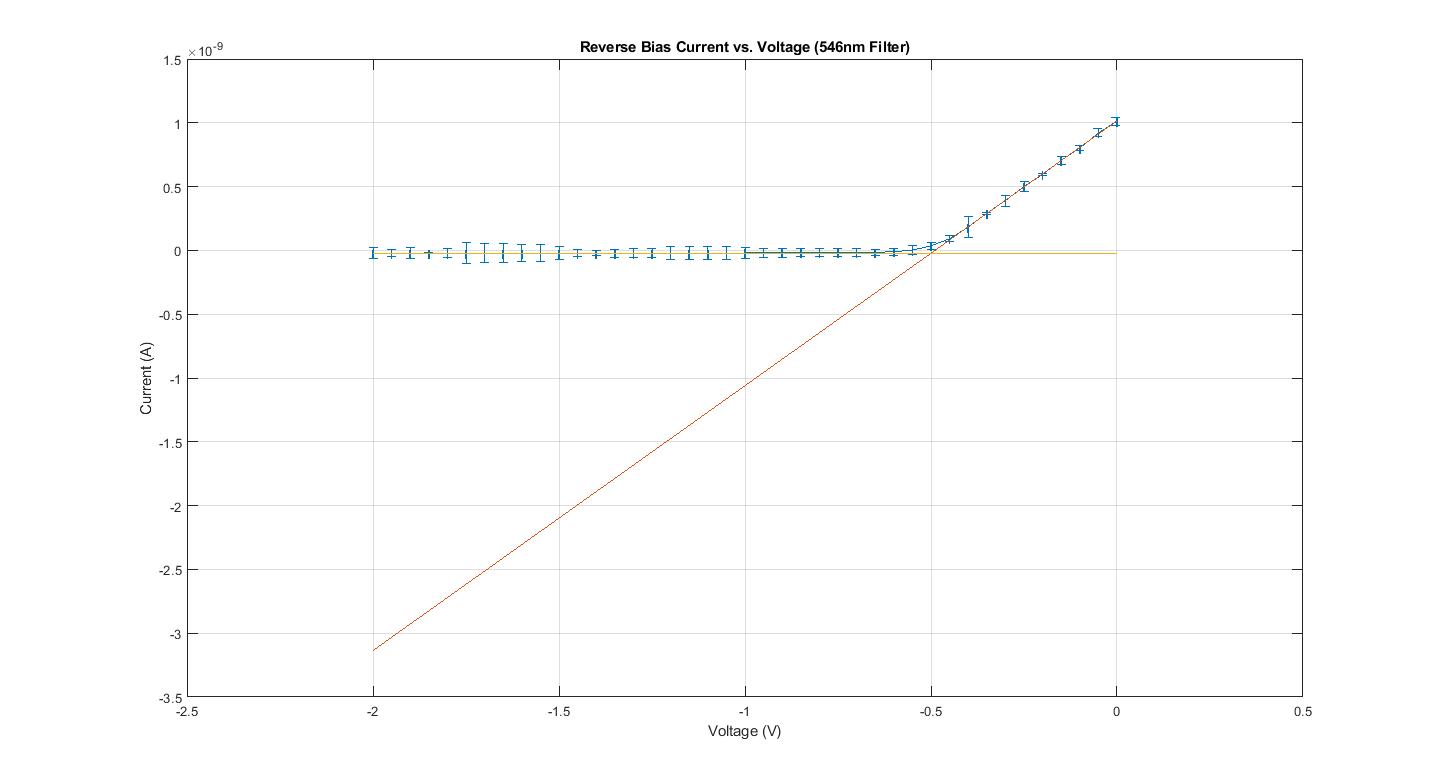
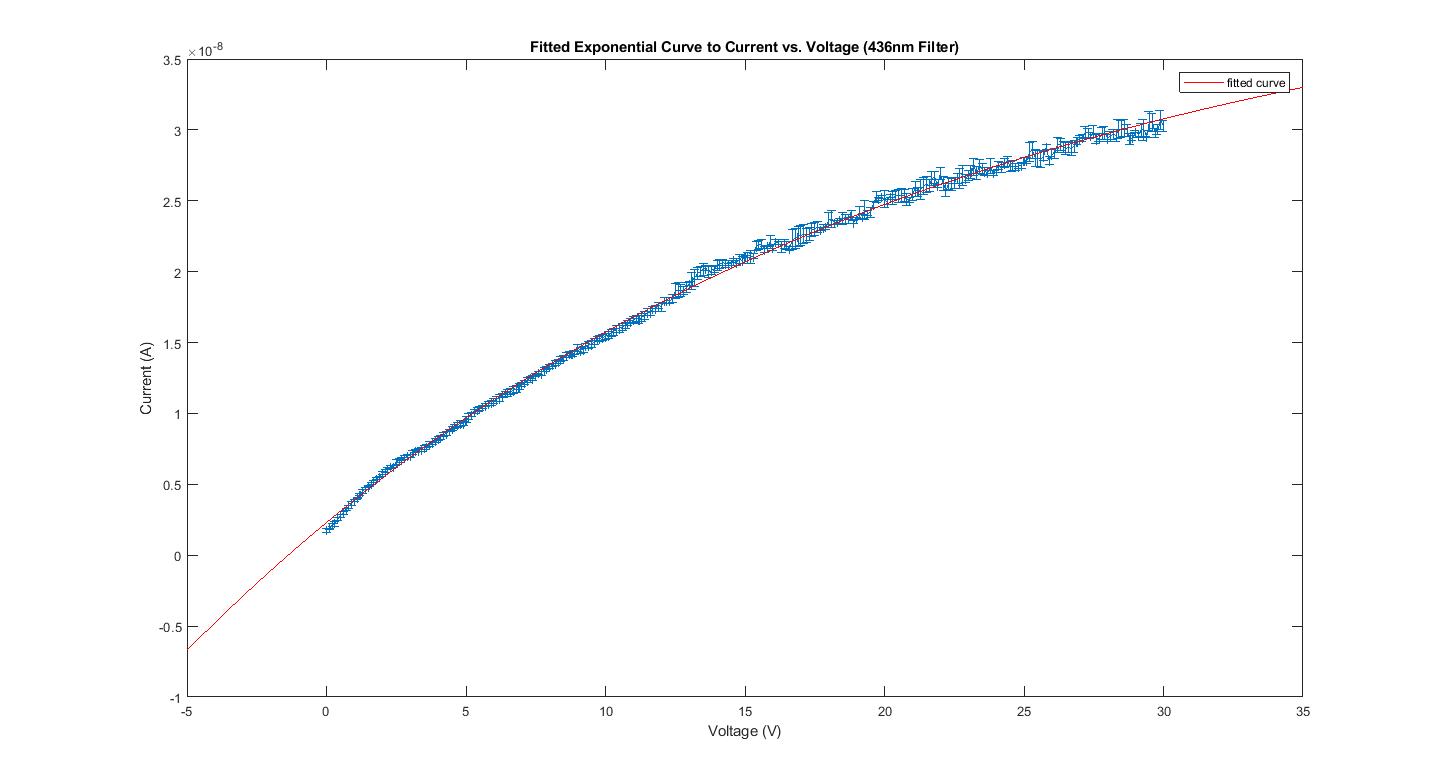
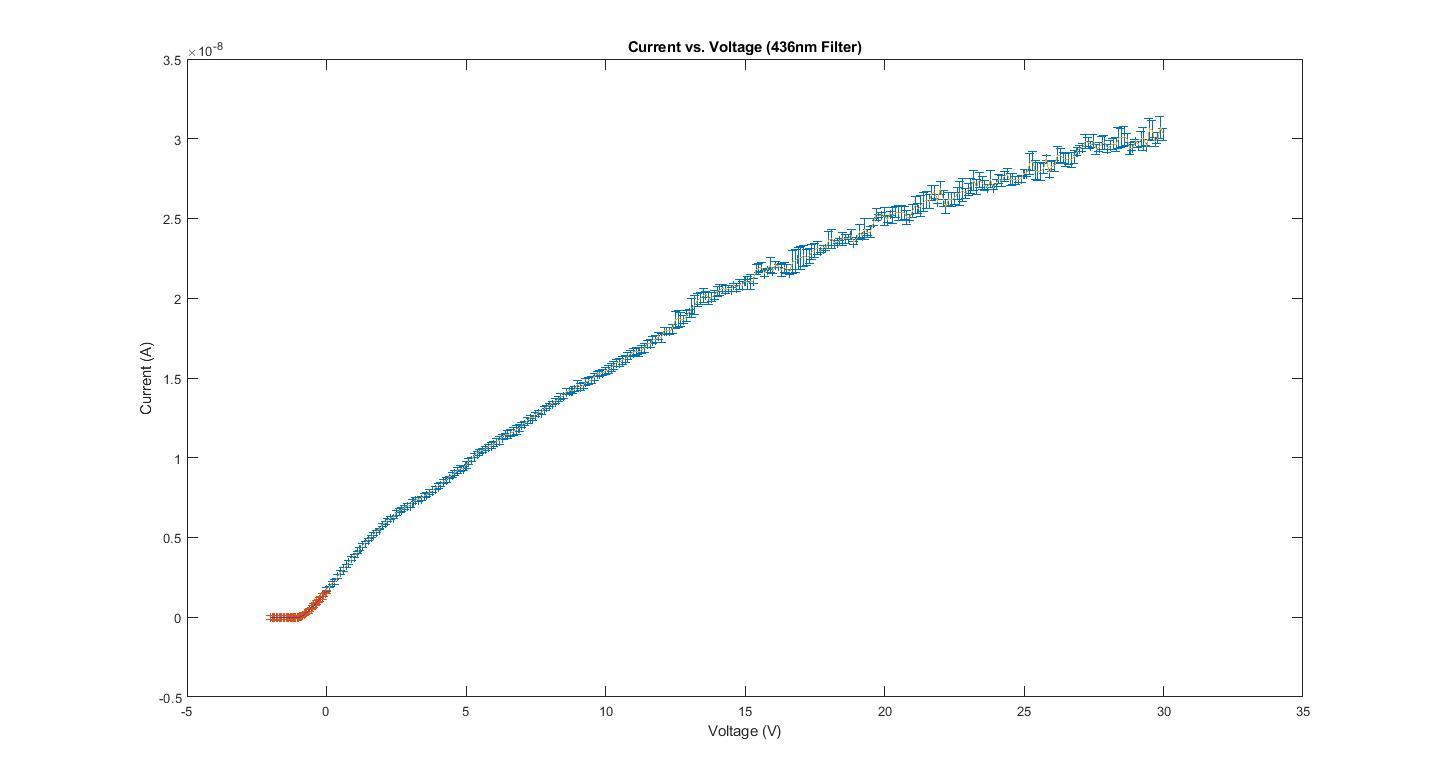


Figure 3: The phototube consists on an applied voltage across two metal plates. As incoming light of a certain frequency hits the top plate, photoelectrons are ejected towards the bottom plate. The phototube shown is currently in a “forward bias” state because the bottom plate is attracting the negatively charged electrons rather than repelling them.

Methods

The first thing we did when collecting data was ensure that the room we were collecting data in could be as dark as we could make it to prevent any stray light from interfering with our light source, the mercury lamp. The next thing we did was power up the mercury lamp. This requires a bit of time to warm up to get to a sustained brightness. Next, we rotated the filter disk to place a desired filter over the opening to the phototube, being careful not to touch the filter lest we dirty it. Next, we connected the power supply to the phototube such that the voltage will accelerate the photoelectrons towards the receiving plate. This will be referred to as “forward bias”. Using the MATLAB script found in Appendix A, we configured the power supply to increase the potential from 0 V to 30 V, incrementing the voltage by 0.1 V. At each step, the picoammeter would measure a value for the current at that voltage. A pause of one second was allowed between each increment and reading. After we had taken measurements from 0 V to 30 V in this way three times, we switched the leads on the power supply in order to reverse the voltage. This position will be referred to as “reverse bias”. Again, we used the MATLAB script found in Appendix A to configure the power supply and the picoammeter to take data automatically. However, this time the setup was configured to take data from 0 V to -2 V, with increments of 0.05V. We repeated taking data in the “reverse bias” position three times. After this, we were done with the first filter, and we repeated the process for “forward bias” and “reverse bias” three times each for each remaining filter.



Results and Interpretation