# Investigating the Effect of Carbon Nanotube Growth Time of Carbon Nanotube-based Radiation Detectors

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## Goals

The carbon nanotube (CNT) detectors that our group fabricates have been shown previously to sense/detect ionizing radiation. The purpose of this study is to narrow down specific aspects of the fabrication process.

## Introduction

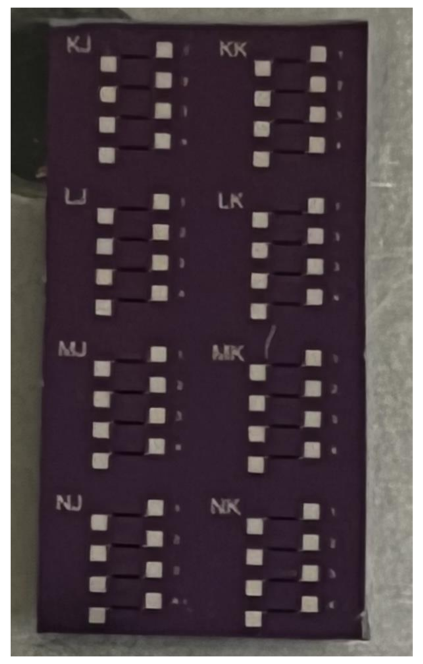
CNT detector devices can be grown with varying chemical vapor deposition CVD growth rates as part of the fabrication process. This study characterized device performance at varying CVD growth rates. It is also known that applying a specified voltage to each device for a specified time “burns out” the undesirable metallic properties of the carbon nanotubes, which make these devices more sensitive to ionizing radiation. These two processes coupled together allows for the fabrication process to begin to be standardized. The relationships between CNT growth time, required metallic burnout time, and device response are reported here. It was found that while longer growth times yielded better performing detectors, the required burnout times also increased.

## Methods

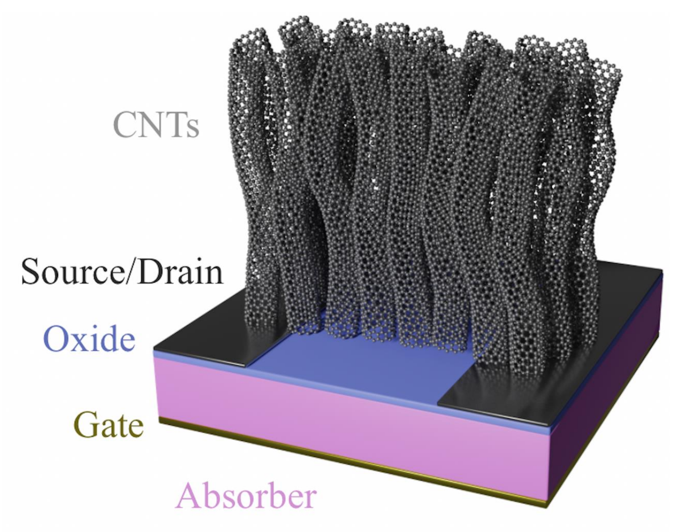
Five sets of CNT detectors were grown with the following CVD growth rates: 10 minutes, 7 minutes, 5 minutes, 3 minutes, and 1 minute. These were then characterized for device performance through a burnout study. Each device was burned three times in 5-minute intervals at a gate voltage of 20 V and measurements were taken between each burn. The measurements taken to characterize each device include an IV curve, and IVg curve, and a real-time current measurement.  It should be noted that for real-time measurements, the burnout plots are combined; all measurements for the Ivg plots are also combined.

## Results

### 8 CNT Detectors

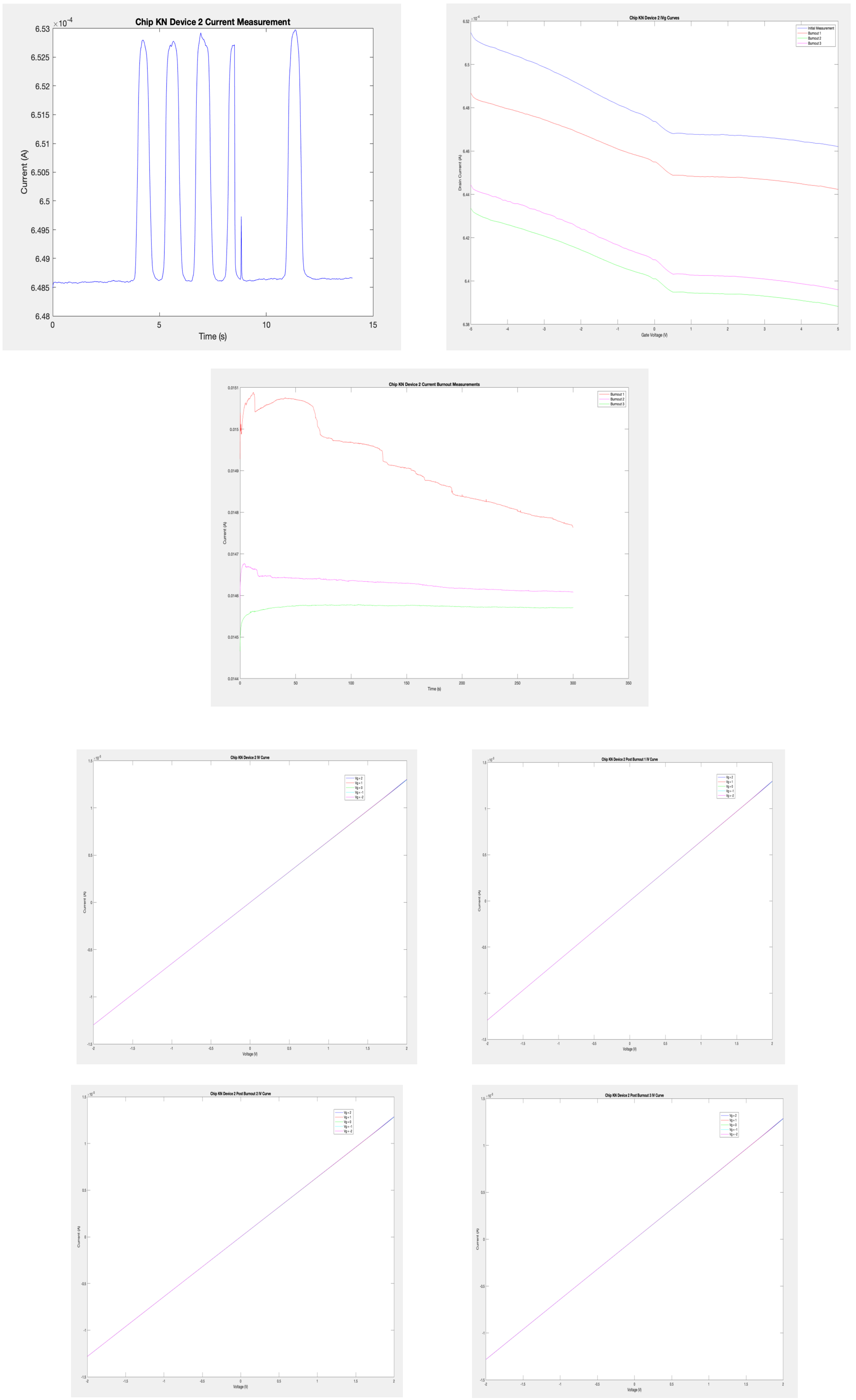



Above are 8 CNT detectors. This is a portion of the detectors used in this study. Each detector has four devices, these are the silver squares, two of these squares make up one device.

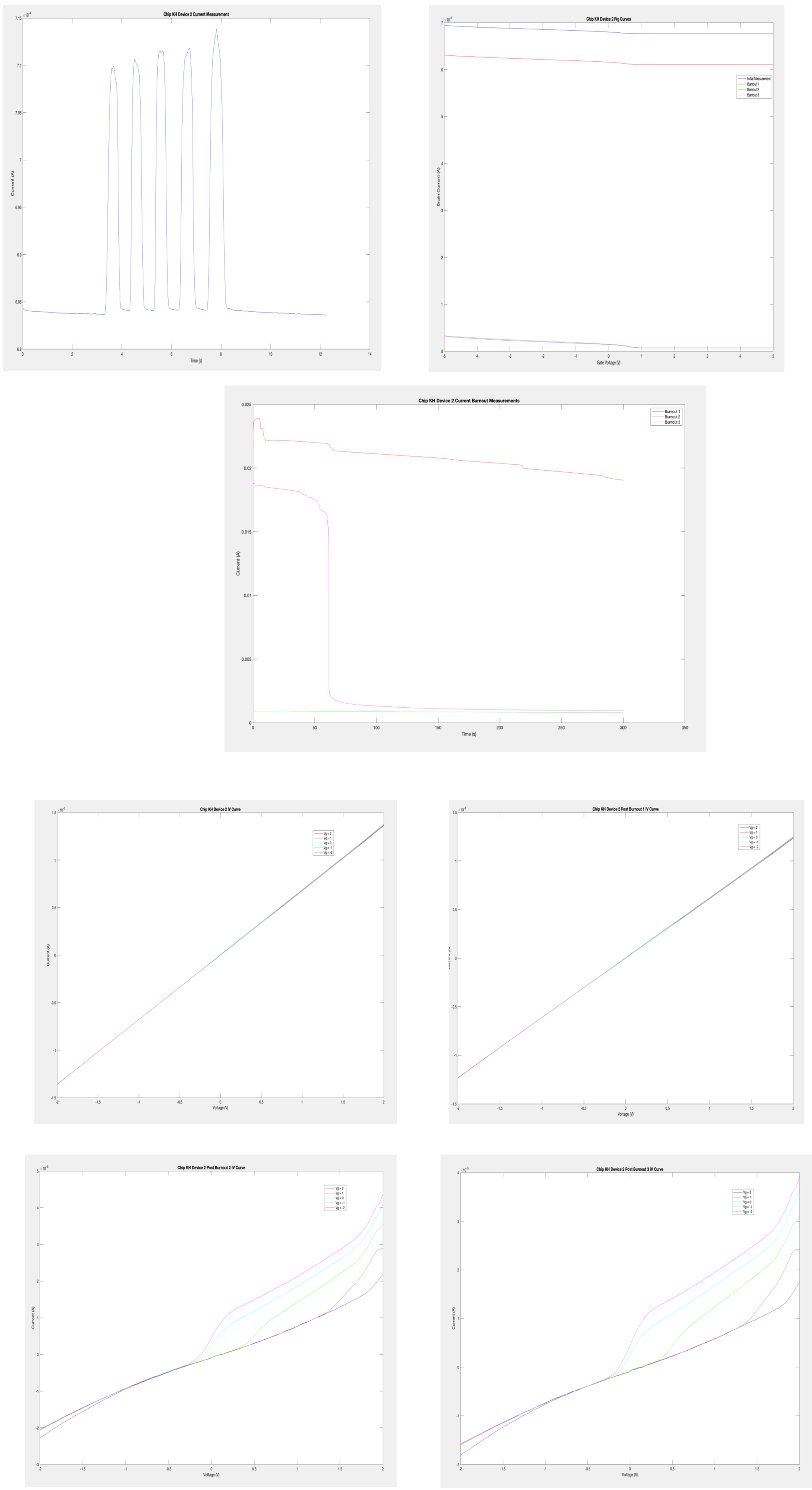



Above is the CNT detector geometry

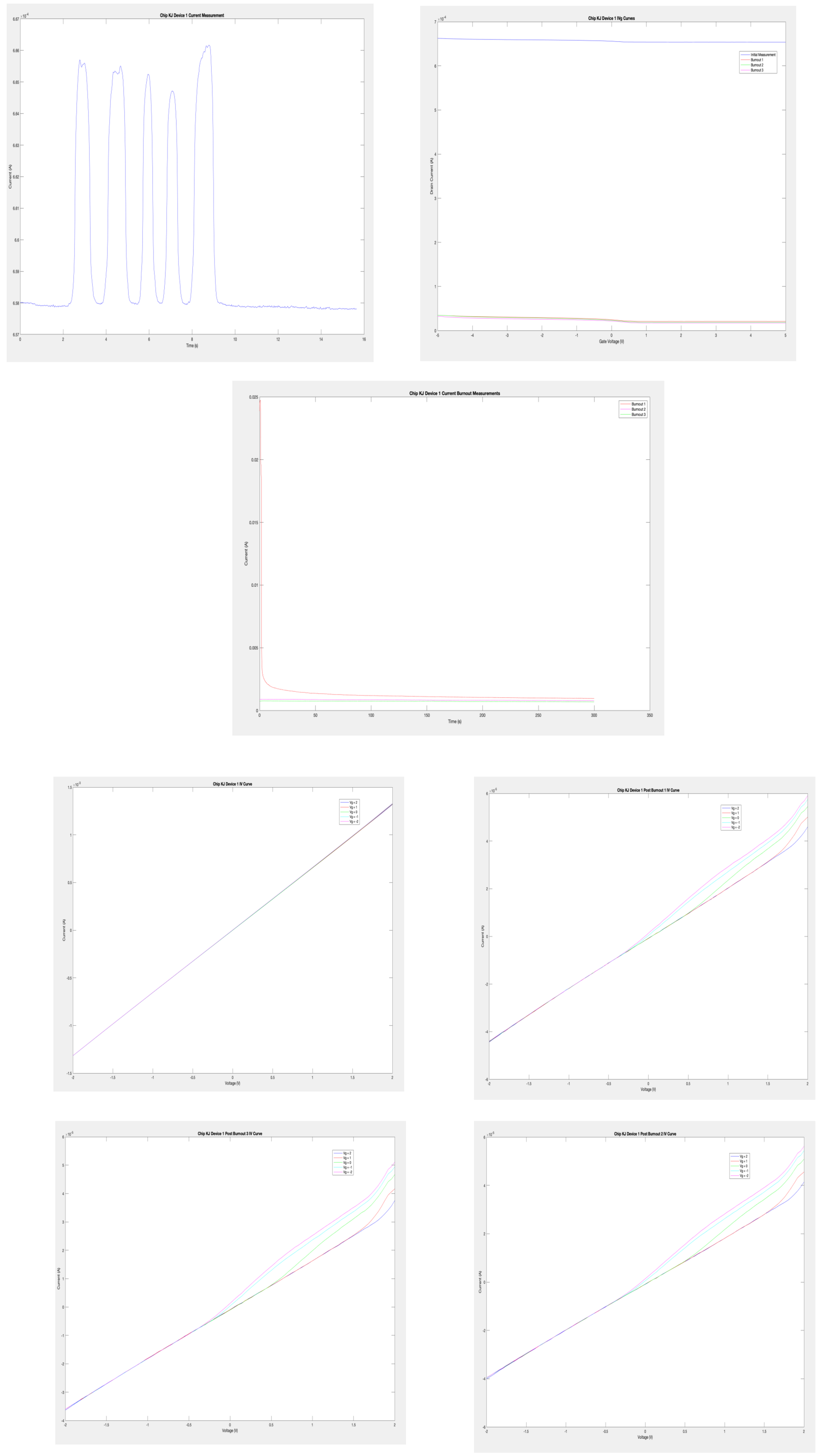
### 10-Minute CVD Growth Rate



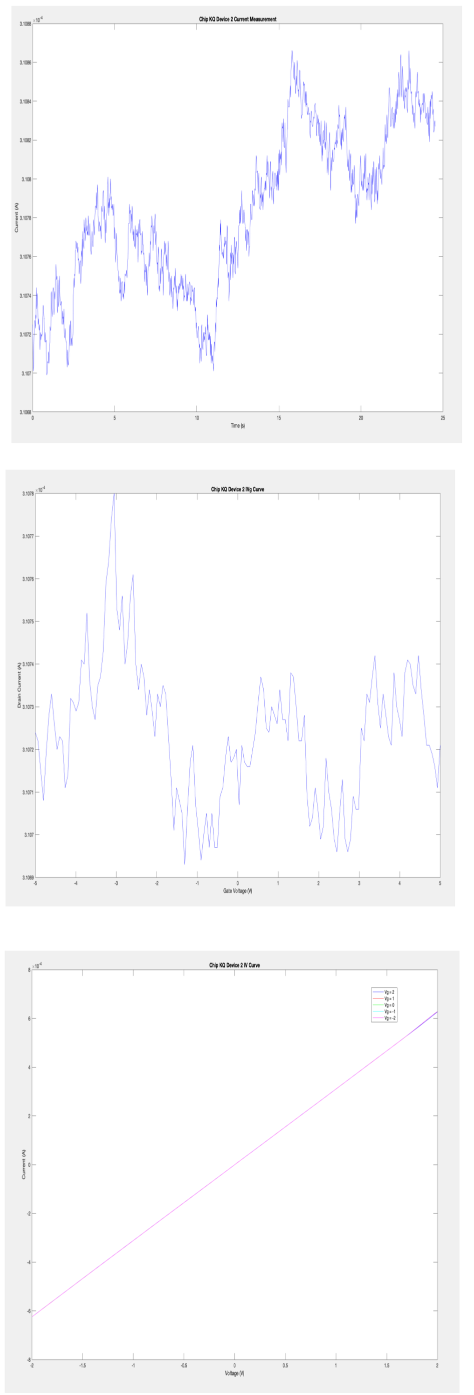

### 7-Minute CVD Growth Rate



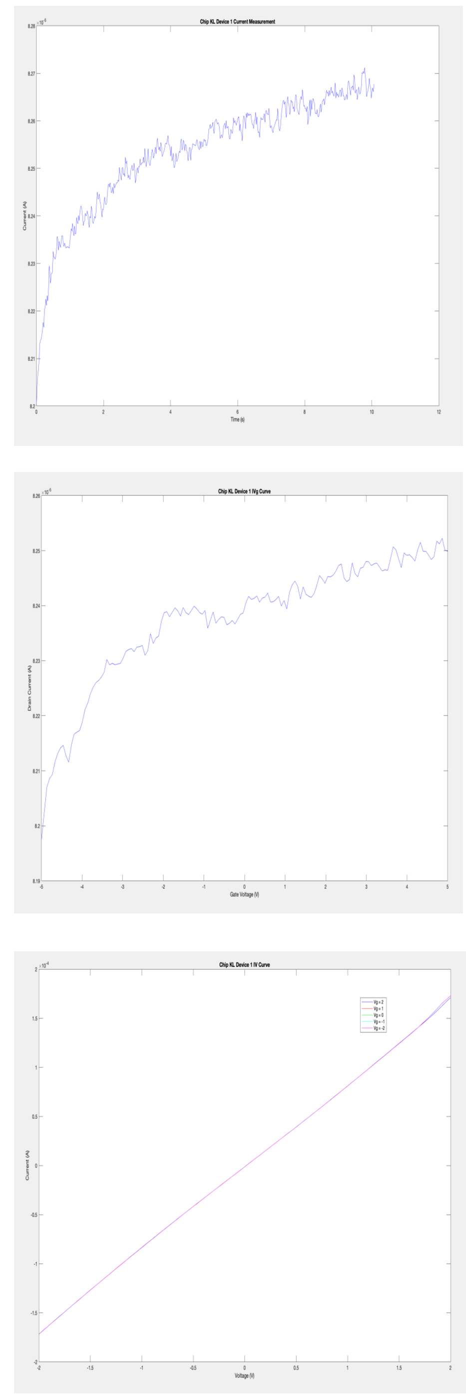
### 5-Minute CVD Growth Rate



### 3-Minute CVD Growth Rate



### 1-Minute CVD Growth Rate



## Discussion/Next Steps

It should first be noted that all devices in the 1 minute and 3 minute sets showed no response, thus, no burn outs were done. Further processing needs to be done on the initial measurements to determine whether the CVD furnace or the lack of CNT growth time is the cause of the no response. Within the rest of the growth rate sets, overall device performance is as follows: 10 minute being the worst followed by 7 minute and then finally 5 minute being the best. This can be seen the best in the IV curves. Separation between the various gate voltage curves suggests optimal detector response. This is seen after only one burnout for the 5 minute growth rate and after two for the 7 minute growth rate. The 10 minute growth rate did not show this separation but from the real-time current measurement, it is clear that this detector is responding but likely needs a longer burnout before this separation is seen. The next stage will first include further processing the device data for MOSFET characterization, then more testing to find the most optimal CVD growth rate to further standardize the fabrication process.

## Conclusion & Relevance to Program Objectives

A burnout study was conducted to characterize CNT detector devices for five sets of CVD growth rates. It was found that while longer growth times yielded better performing detectors, the required burnout times also increased. The best performing devices were at the five minute growth rate. Overall, our CNT detectors can sense ionizing and give various measurements in real-time. These detectors, once standardized, will be able to be mass produced at a relatively low cost and have a variety of applications from medical dose monitoring to nonproliferation efforts.

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