Nanoelectronics Undergraduate Research Fellowship (NURF)
2010 Project Summary

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Faculty mentor name: Dr. David Go
Project title: Experiments in microscale gas discharges

A microdischarge is the transmission of current through a gas between electrodes separated by a distance of microns. A discharge occurs after a sufficiently high electric field has been applied that causes the gas to become a conductor. This process is called breakdown and is brought about by an exponential growth in electrons. There are several modes of electron growth, one of particular interest for this research has positive ions bombarding the cathode and extracting electrons. In addition to extracting the electrons, the energetic ions erode the cathode by heating and sputtering material away. This field is particularly relevant in the realm of sustainability and is widespread in its applications. The capability exists now to use microdischarges in environmental remediation to remove harmful pollutants from the atmosphere. Microdischarges can also be used to monitor environmental conditions such as air composition and level of contaminants. A current limitation of microdischarges is that the electrodes, and cathodes in particular, accrue a large amount of surface damage after limited use. The purpose of this research is to quantify the surface damage of electrodes and look for trends among parameters in order to identify operating configurations and conditions that limit damage.

I devised two experiments to investigate the effects of electrode gap distance and voltage on electrode damage. A silicon wafer covered with 400 μm of titanium and a stainless steel needle were positioned perpendicularly for both experiments. For the first experiment, voltage was held constant at 3000 V while distance varied. A voltage was applied for 5 seconds at different points on the wafer at an electrode distance of 800 μm, 400 μm, 200 μm, and 100 μm. The damage area was then imaged using an SEM and the surface roughness was quantified using software available through the SEM. Figure 1 shows the titanium electrode after the microdischarge.

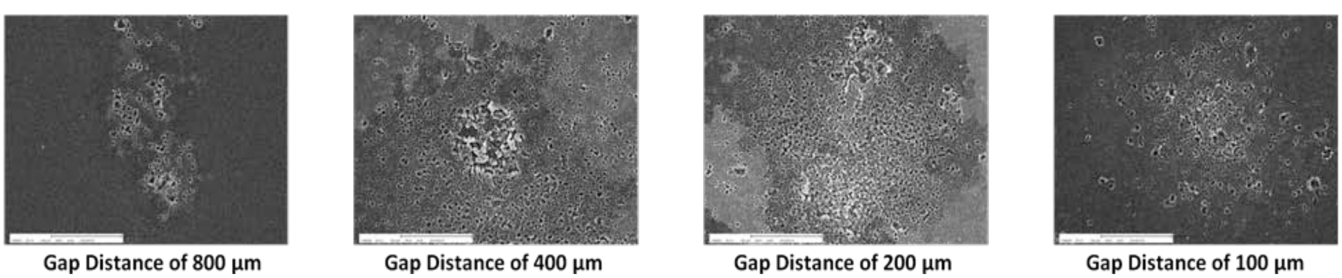

Figure 1: SEM Images of titanium electrodes at a magnification of 300

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Figure 2 shows the surface roughness percent increase against the gap distance, and a clear inverse relationship can be seen.

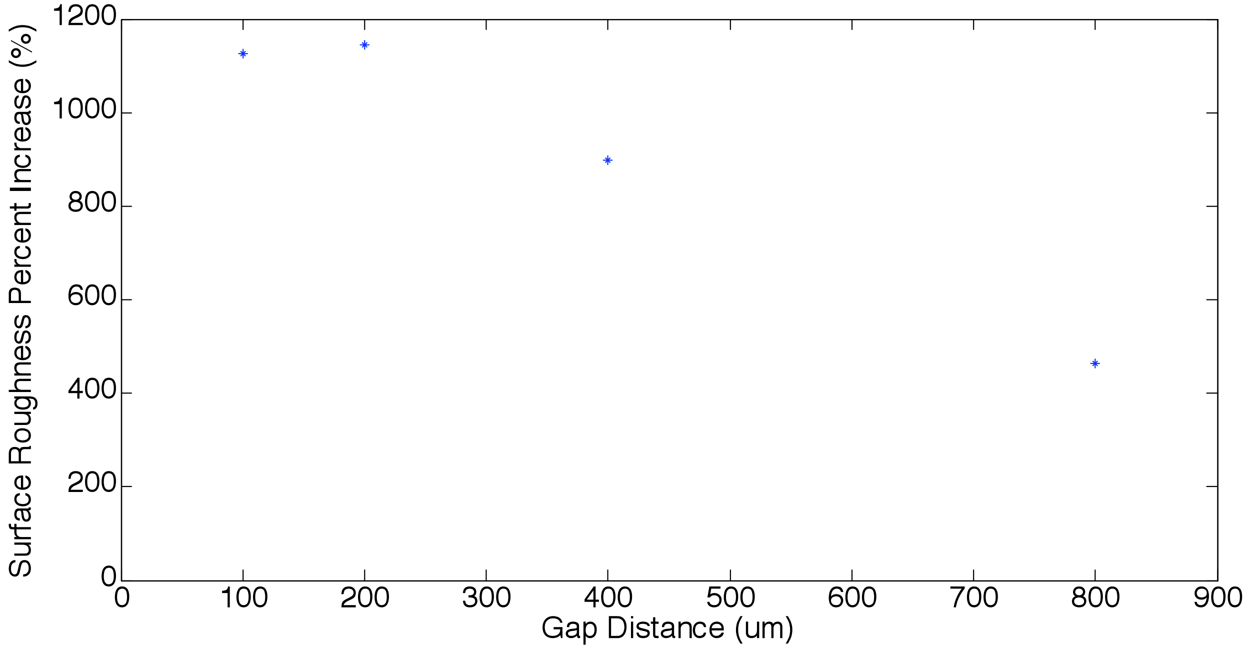

Figure 2: Surface roughness percent increase of the titanium wafer versus gap distance

The second experiment held the gap distance constant at 100 μm while varying the voltage. A voltage value of 2000 V, 3000 V, 4000 V, and 5000 V was applied for 5 seconds to different areas of the wafer, and an SEM was used to image and quantify the damage as in the first experiment. The surface roughness percent increase and voltage displayed a direct relationship. Future research will continue to look at the relationship between voltage, gap distance, and damage, this time in a low pressure environment. Additionally, I will begin to investigate the effects of electrode material on electrode damage.

Publications:
Examining Damage of Titanium Electrodes After Microdischarge (poster) - to be presented by Dr. Go at the MIND annual workshop.