Fabrication of a Schottky Diode

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Introduction

The Schottky diode is a circuit component with exhaustive applications in microwaves, GPS tracking, and solar panels. Unlike rectifying diodes formed by a PN junction, a Schottky diode is established when a metal is joined to a doped semiconductor. This subtle difference in the Schottky diode produces a rectifying IV curve as well as superior switching speed and lower power dissipation when compared to the rectifying diodes According to physics teacher article Volume 58, Issue 1, Schottky diode properties can be replicated with a silicon wafer, a hot lamp, gold leaf foil, and aluminum foil. However, the Schottky barrier diodes created by this process failed to match the rectifying behavior of the commercial 1N4001 rectifying diode in reverse biases for N-type silicon. Throughout my research, I will refine the experimental procedures to create a Schottky barrier diode with correct rectifying behavior under both forward and reverse bias conditions.

Methods

Wafer preparation

- Twelve 1”x 1” and ten 1/2 ”x 1/2" phosphorus-doped silicon wafers prepared with PELCO Flex Scribe 200

Hydrofluoric Acid Wash

- SiO_2 layer etched off by submerging wafers into Lodyne buffer oxide etchant 15:1
- A wettability test was used to confirm the removal of the SiO_2 layer.
- Once SiO_2 removal was complete, the wafers underwent a DI wash as seen in Figure 2and then air dried

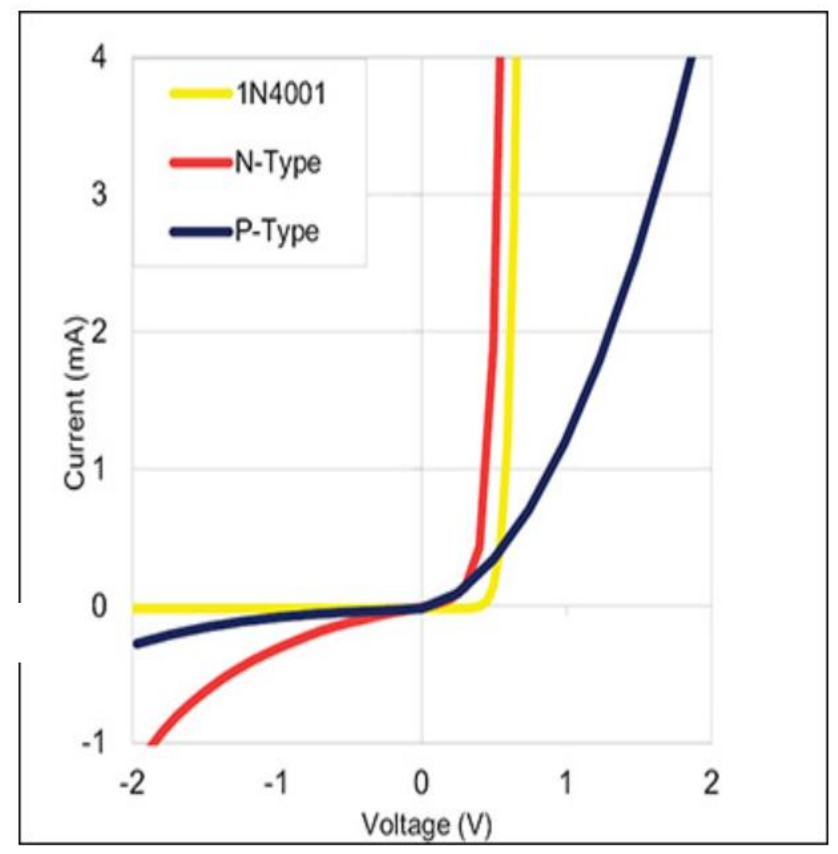
Sputter Deposition

- Once the etched samples were rinsed and dried, they were placed in the Denton vapor deposition chamber for the sputtering process.
- After five minutes, a 100-nanometer-thick layer of gold would be deposited onto the silicon wafer.
- The samples were flipped, and the process was repeated a second time.

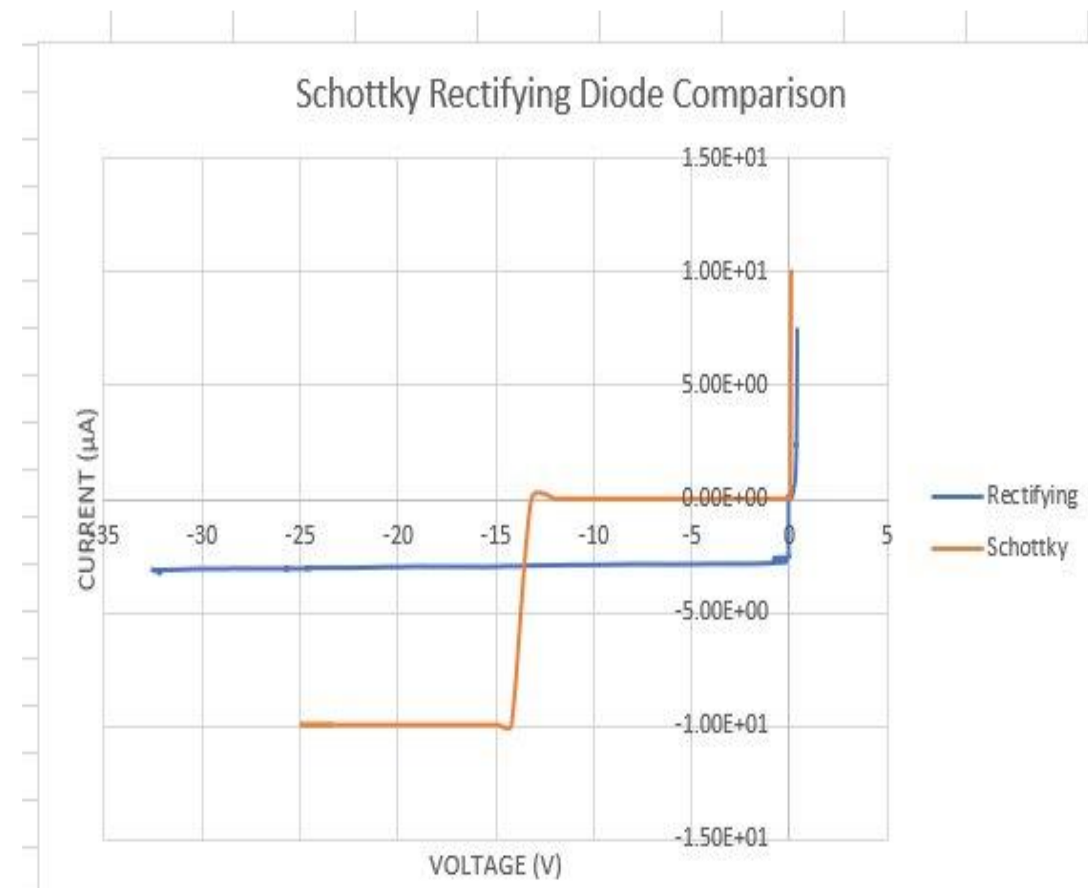
Data Collection and Processing

- Fully prepared Schottky diodes were placed on a breadboard to obtain an IV curve using a LabVIEW program.

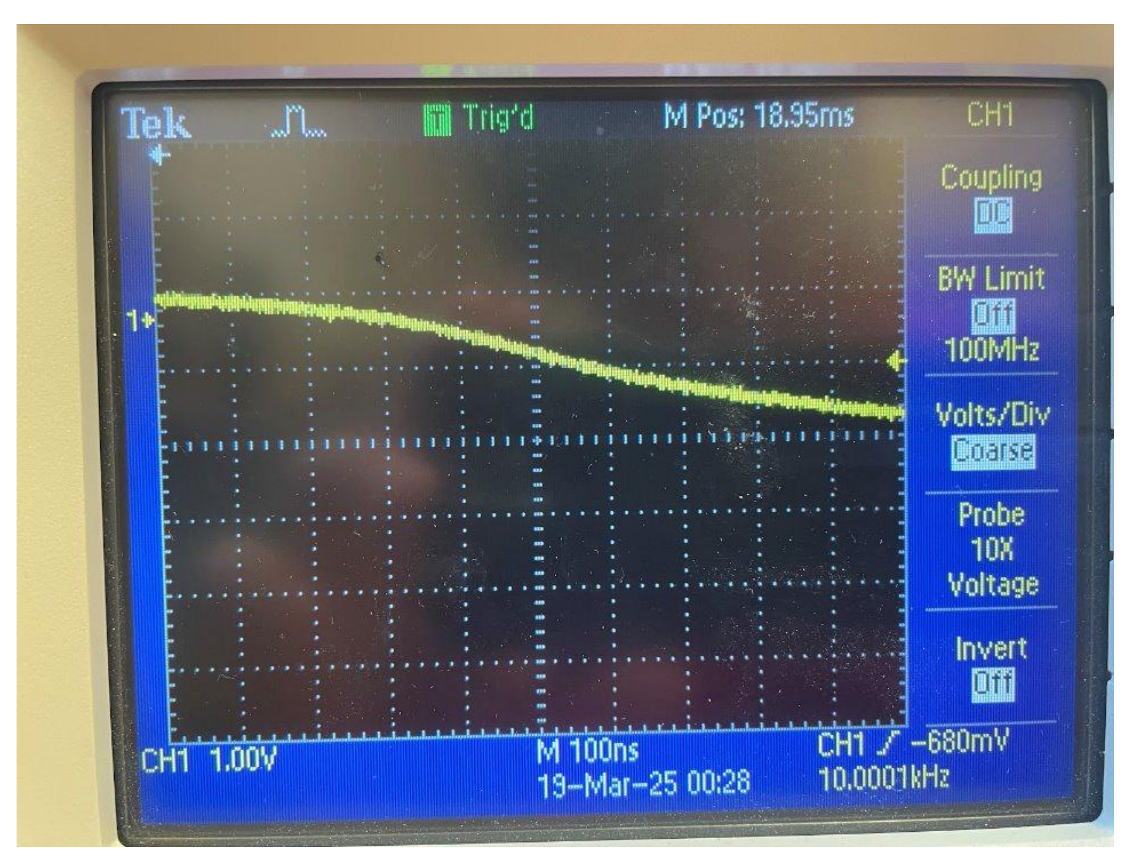
Results



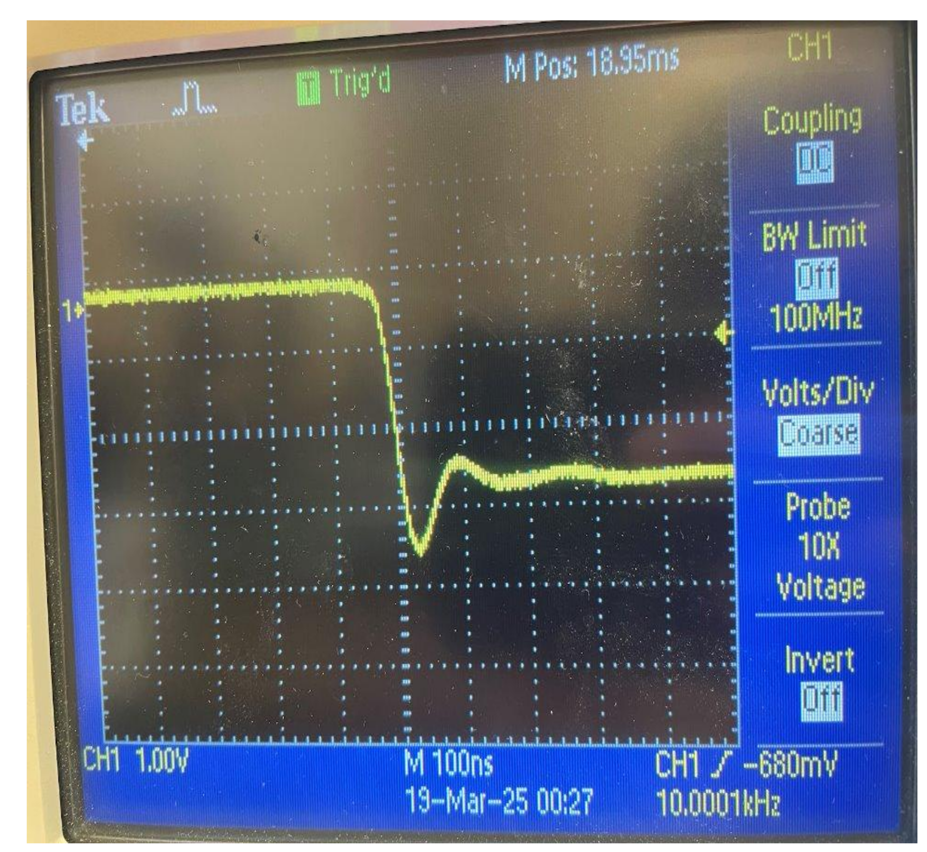
Graph 1: IV curve from the physics teacher’s article



Graph 2: IV curve comparison between Schottky and Rectifying



Graph 3: Switching speed of 1N4001 Diode



Graph 4: Switching speed of Commercial diode

Acknowledgments

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References

1. Michael, S. (1990). Physics of Semiconductor Devices. Englewood Cliffs, NJ. Prentice Hall
2. Pauline Stevic (2018). BOE/HF – Silicon dioxide Etching Standard Operating Procedure

Analysis

The HF wash etch successfully removed the SiO_2 layer that covered the wafers. However, the layer would quickly grow back when exposed to the atmosphere. This problem made data collection on the fabricated impossible due to the SiO_2 layer high resistance. Experiments that used dry etching in a vacuum chamber proved more successful, but to prevent a new layer from forming, the diode must be wholly encapsulated with either gold or aluminum

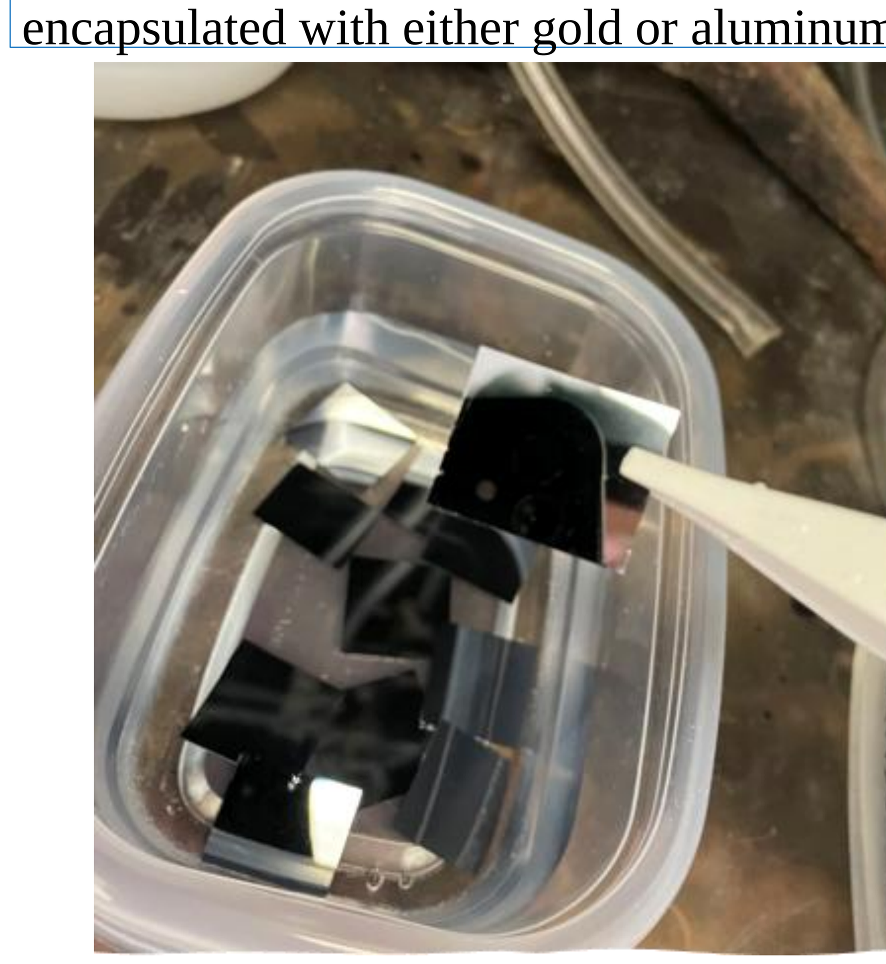

Figure 2 HF, DI wash

Future work

Parameters to change:

Material types:

- Chromium
- Platinum
- Tungsten

Etching method

- OH wash
- Plasma dry etch

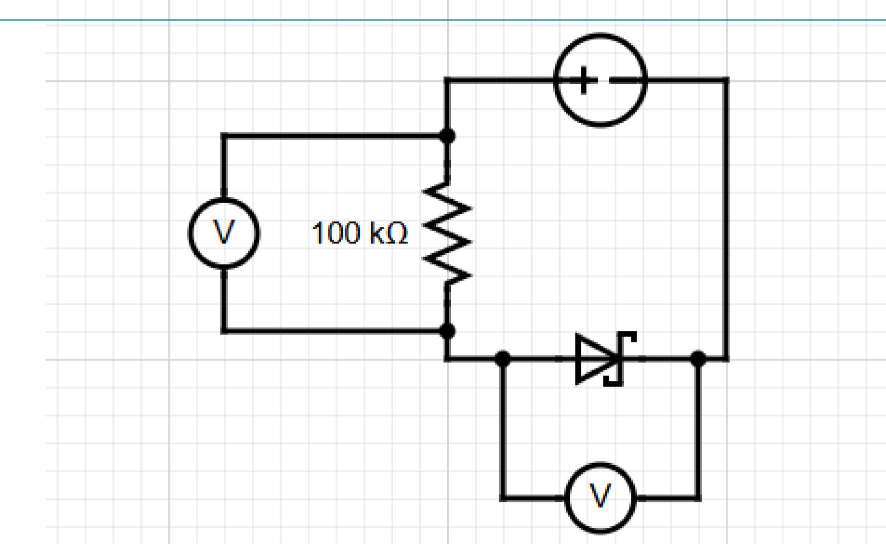

Figure 1, Schematic Diagram of breadboard circuit