# Photoelectrochemical Etching of Silicon Carbide

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## Abstract

**Silicon carbide (SiC) was etched by photoelectrochemical (PEC) in a dilute solution of hydrofluoric acid (HF). PEC etch masks were formed on SiC by sputtering 10 nm of titanium and evaporating 150 nm of platinum and heating the contacts to 600ºC by rapid thermal annealing. PEC etching was performed with a UV light power density of 125 mW/cm$^2$ and a current density 0.992 mA/cm$^2$. Etching was performed for one hour at room temperature. The SiC nanopores were then oxidized at 1150ºC for four hours to form $SiO_2$ and subsequently placed in an HF solution to remove the oxide.**

## Introduction

SiC is so chemically resistive that only a few techniques are available to etch it. Hot potassium hydroxide (KOH) will etch SiC, however KOH will also remove almost all etch masks. Reactive ion etching (RIE) can be used to etch SiC also and a suitable etch mask exists for this process. RIE has very high anisotropy and good morphology, but it's an expensive process with no dopant selectivity. It does have a low etch rate but depending on the application, this can be considered an advantage or disadvantage. Photoelectrochemical etching has a more controlled etch rate from low to very high. It yields good morphology on 6H-SiC and excellent dopant selectivity. It's relatively inexpensive when compared to RIE, but only has fair morphology on 3C-SiC [1].

Photoelectrochemical etching is the process of using ultraviolet light, voltage, and chemicals to etch materials such as silicon carbide and gallium nitride. Pure silicon carbide is not a good conductor of electricity so its essential that silicon carbide be n-doped meaning more electrons are present than holes. Through photoelectrochemical etching, holes are generated with ultraviolet light by breaking some of the bonds in the SiC (Figure 1). Voltage is applied to the sample forcing holes to the surface of the sample to facilitate etching by hydrofluoric acid.

## Experimental Procedure

First we characterized titanium/platinum (Ti/Pt) contacts on SiC as an etch mask by sputtering 10 nm of Ti and evaporating 150 nm of Pt and heating the contacts to 600ºC by rapid thermal annealing. The process of annealing makes sure that the Ti/Pt mask fully adheres to the surface of the SiC sample. SiC nanopores are formed on the substrate surface by PEC. PEC conditions for nanopore formation were: UV light power density of 125 mW/cm$^2$ and a electrical current density of 0.992 mA/cm$^2$ in a dilute solution of HF. Etching was performed for one hour for both 3C and 6H SiC. Nanopore formation was followed by oxidation of the SiC nanopores in a wet oxidation furnace for 4 hours at 1150ºC which changes the SiC nanopores to $SiO_2$. Finally a chemical etch of the newly formed $SiO_2$ was performed in HF.

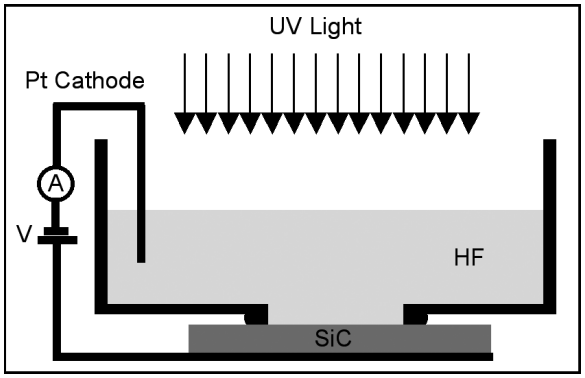


*Figure 1: Photoelectrochemical setup.*

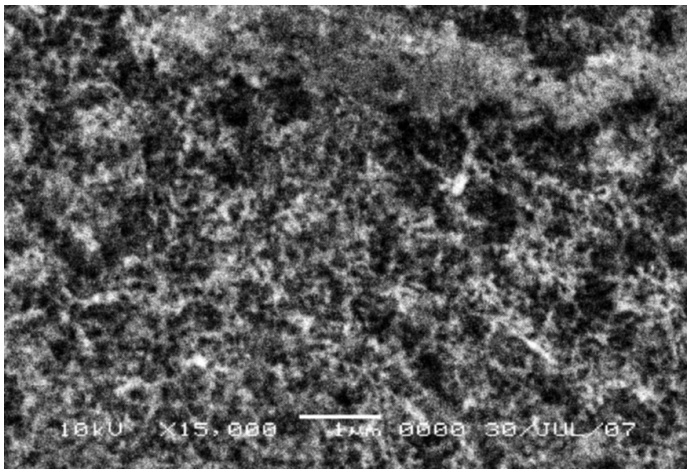


*Figure 2: Porous silicon carbide.*

## Results

We produced nanopores on the surface of the SiC through PEC as seen in Figure 2. After oxidation, we could tell from the surface of the SiC sample that $SiO_2$ had formed because of the blue color that was visible on the sample where the nanopores were. $SiO_2$ was then removed with HF. We obtained etch depths of 13 $\mu$m for the 3C-SiC and 4.6 $\mu$m for 6H-SiC. Since 3C has a less dense lattice, we were able to obtain higher etch rates. Figure 3 is an SEM image of a 6H-SiC PEC etched sample.

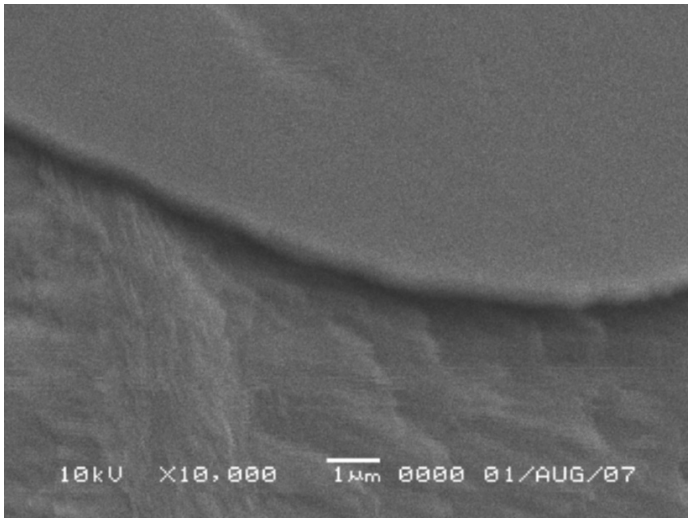


*Figure 3: 6H-SiC after PEC etch.*

## Conclusion/Future Work

In conclusion, we were successful in forming nanopores, oxidizing the nanopores to form $SiO_2$, and removing the $SiO_2$ to get a clean etched surface on SiC. However we did have issues with getting the Ti/Pt mask to fully adhere to the SiC surface. We were able to solve this issue by heating the sample at 600ºC. Some samples were not etched because they were either undoped or low doped. In the future it would be beneficial to establish etch rates on 3C, 4H and 6H SiC based on doping concentration.

## Acknowledgements

I would like to thank Dr. Gary L. Harris, Mr. James Griffin, Dr. Peizhen Zhou, the staff and students at HNF. I would also like to thank the National Nanotechnology Infrastructure Network Research Experience for Undergraduates Progam and the National Science Foundation for funding.

## References

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