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Electrodeposition of Boron Fiber

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Boron Fiber Study

Background

My project was studying how to improve diamond cutting wire techniques using a stronger material for the wire, trying to replace the conventional steel normally used in these techniques with boron fiber. My goals for this semester were to further advance the knowledge of this project. This was done by learning about the instrumentation techniques required to conduct experiments (SEM and electrodeposition) and applying those concepts to the material I have been working with.

The main material in this project was boron fiber. Boron fiber was obtained from Specialty Materials with a product name of Boron Filament. The boron fiber obtained is amorphous boron with a fully borided tungsten core. The diameter given by the specifications 102 nm. The diameter was also measured by an experimental method. The inner core diameter of 16.875 nm was obtained with an outer diameter of 100.46 nm. The SEM image of these measurements are shown in Fig. 1 and Fig. 2. This was done by taking a picture of a cross section using an SEM and measuring the distance using a ruler tool. The inner core of the boron fiber is more conductive than the outer core (Tsirlin). This proves important when doing electrodeposition.

Studying the electrodeposition techniques on this wire was necessary because eventually, the diamond power would be attached to the wire using this technique, because as whatever element in the solution would coat the fiber, it would also pull the diamond along, forming a coating with both.

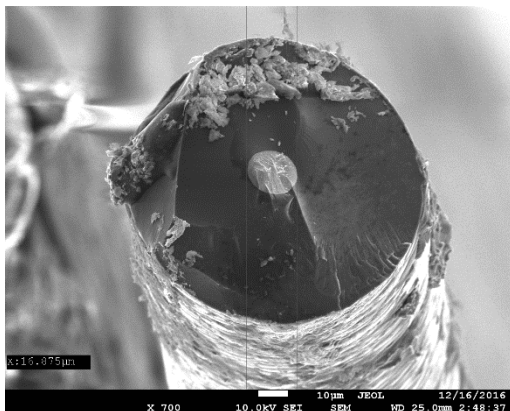


Figure 1 Inner diameter measurement of filament

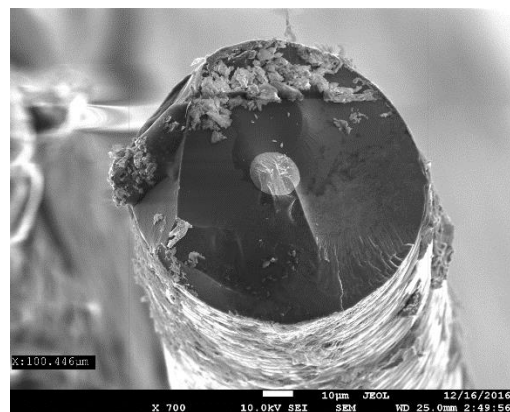


Figure 2 Outer diameter measurement of filament

Abstract

From previous experiments, it was determined that nickel was able to coat boron fiber, however this was done unevenly, with cracks characterizing the coating. This was where it was hypothesized that the boron fiber crossed the interface of the nickel electrolyte solution during electrodeposition. This was different than the coating at the middle, which was all under the electrolyte solution, and was characterized by a smoother surface.

This experiment sought to find a way to coat the nickel across the boron fiber wire evenly. SEM images were taken at the top and at the middle of the fiber. An overview picture of the area the SEM was taken, and then zoomed in on to focus on the surface characteristic (the overview was taken at x500 and the zoomed in version was taken at x950). From the images gathered, it was able to be concluded that the cracks characterizing the surface at the top of the filament from earlier experiments were not present.

Experimental

The boron fiber was cut into a five centimeter piece. Impurities were removed from the surface using ultrasonic cleaning to allow the fiber to be able to form strong bonds during electrodeposition. When that was done, the top 1 cm was coated with silver paint. This was done to allow the current from the equipment to flow more easily into the boron fiber. The next two centimeters were coated with epoxy. This epoxy was coated for the length specified so that during electrodeposition, the epoxy would block the interface between the nickel electrolyte solution and the air. The next 1.5 centimeters were not treated for electrodeposition to occur on them. The last .5 centimeter was coated with epoxy, taking care to coat the cross section to block the inner core from the electrolyte solution, to prevent current from going through the wire and force it to radiate outwards through the boron fiber.

The boron fiber then went through electrodeposition. The fiber acted as a working electrode and was plated with nickel from the electrolyte. This process worked by using a copper tape coated with platinum as a counter electrode and a reference electrode to measure the potential of the working electrode. The electrodeposition was run for an hour.

After the electrodeposition, images were taken of the boron fiber at the top interface and in the wire length using SEM. From these images, the surface characteristics were able to be obtained.

Results and Discussion

The results of the SEM are shown in Fig. 3, Fig. 4, Fig. 5 and Fig. 6. Figure 3 and Fig. 5 are images taken of the boron fiber at a magnification of 500. These images were then focused down to a magnification of 950 to more closely examine the surface features. When examining the surface, it can be concluded that the electrodeposition at the top of the boron fiber was similar to the electrodeposition at the bottom. At both points in the boron fiber, there was a plated surface speckled with dots. These images showed that there were no differences between the electrodeposition in different areas of the wire, in contrast with the cracks appearing in the previous experiment.

This could be because the wire at the interface between the nickel solution and the air was covered by epoxy, and therefore, did not affect the electroplating. Therefore, the images had no reason to appear different from each other.

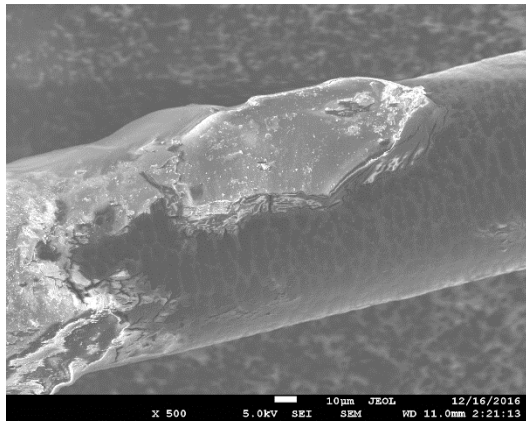


Figure 3 Epoxy interface of coated boron filament

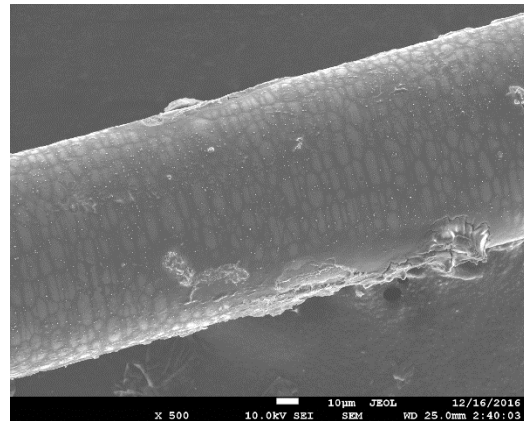


Figure 4 Middle of coated boron filament

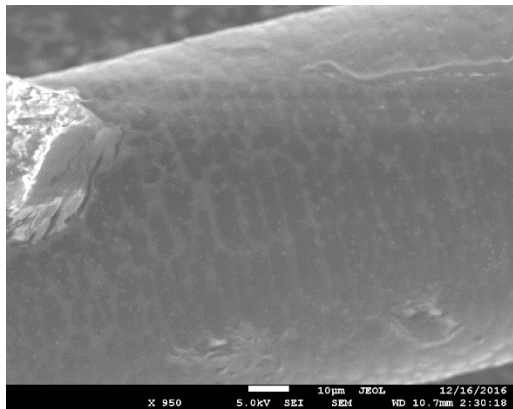


Figure 5 Epoxy interface of coated boron filament (950 mag)

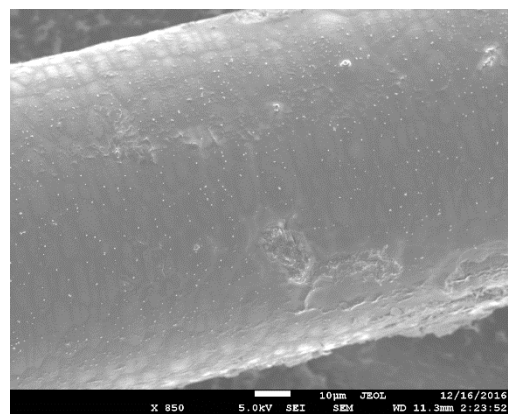


Figure 6 Middle of coated boron filament (950 mag)

Conclusion

By conducting this research, I accomplished my goal of contributing more information to the topic of improving the process of diamond cutting wires. This was accomplished because a methodology for the electrodeposition of nickel on boron fibers was created. I also learned more about the science behind boron fiber and the theory and methodology of operating SEM and electrodeposition systems. Further steps that can be taken is to take even more magnified images of the surface of the coated boron fibers to more accurately assess the characterization. A methodology of coating the boron fiber with diamond powder must also be created.

References

1. Tsirlin, A. "The Electric Resistance of Boron and of Tungsten Borides in Boron Filaments". *Journal of the Less Common Metals*, vol. 67, 1979, pp. 137-141.