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Depth of Aluminum Oxide Contamination Due to Tumbling of SRF Cavities

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Measurements are done to determine the depth of Aluminum contamination in Niobium material of a Superconductive RF cavity that underwent tumbling with Aluminum Oxide rocks. This analysis is performed using a scanning electron microscope and repeated chemical etching of niobium samples extracted from the cavity wall.

I. INTRODUCTION

Tumbling is a mechanical grinding process. It has been used at KEK to process SRF niobium cavities. Cornell SRF group is looking at this process for two purposes. One is to tune the 2-cell ERL injector cavity by removing material from the cavity inner surface. The other is to smooth the mechanical irregularities on the RF surface of a niobium cavity so as to reduce local enhancement of surface magnetic field. The contamination in niobium should be removed by chemical etching after this experiment determines the depth of Aluminum contamination in niobium of a cavity tumbled for at least 48 hours at a rotation speed of about 70 RPM.

II. EXPERIMENT AND RESULTS

Two samples were used in this experiment, sample 1 and sample 2. Sample 1 is a core sample from the tumbled cavity approximately 1/2" in diameter that was extracted from near the equator. Sample 2 is a control sample of single crystal niobium that was used as a reference for Aluminum contamination. Sample 1 was then examined using scanning electron microscopy and energy dispersive x-rays, aluminum concentration was determined in three unique areas of sample 1 measuring approximately 1mmx1mm in area: edge, center and opposite edge. Fig. 1 is a virgin picture of sample 1 that was taken using a scanning electron microscope (SEM). The white dots represent Aluminum contamination in sample 1.

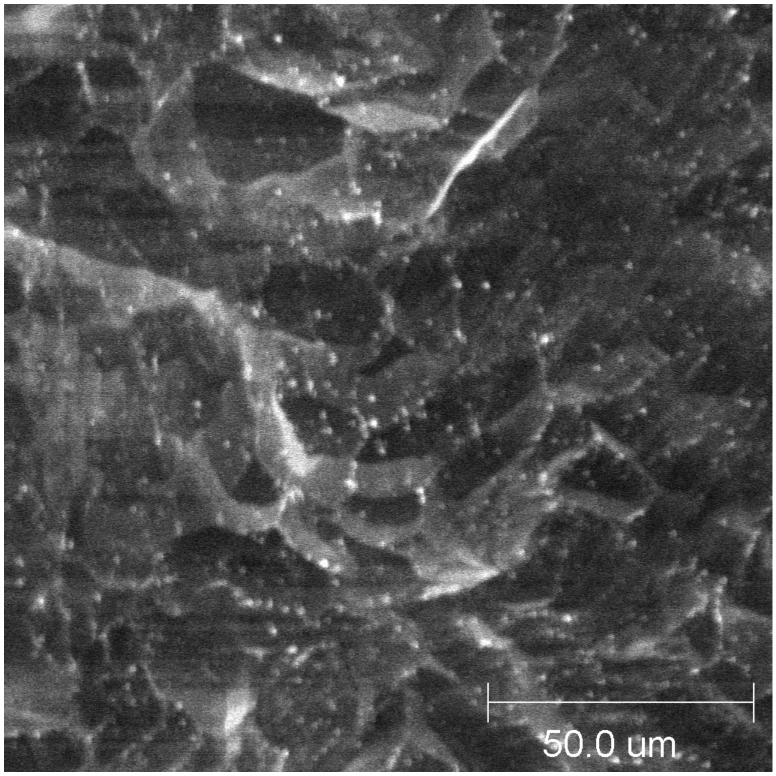

FIG. 1: picture taken using a SEM showing Aluminum contamination represented by the white dots

After results were recorded, sample 1, along with sample 2 were chemically etched in a BCP 1:1:2 bath for five minutes at room temperature. The approximate rate of chemical etching is 2μm per minute. After the first chemical etching, samples 1 and 2 were re-examined using scanning electron microscopy and energy dispersive x-rays. This was done repeatedly until samples 1 and 2 were chemically etched to an approximate 76μm. To determine whether sample 2 was contaminated with Aluminum from being chemically etched in the same mixture as sample 1, a new control sample was examined. This new sample was a scrap piece of niobium that was used in making a 2-cell ERL injector cavity. The new control sample was BCP 1:1:2 etched for 30 minutes at room temperature in a fresh batch of chemicals. After conclusive testing of the new control sample it was determined that the original control sample was not contaminated. Original sample 2 data will be used throughout the rest of the experiment. Fig. 2 is a logarithmic graphical representation for the levels of Aluminum contamination in sample 1. The x-axis is the amount of BCP 1:1:2 chemical etching that sample 1 underwent. The y-axis is indicative of the intensity of Aluminum contamination in counts per cycle. The three lines are the count rates of the highest, lowest and the average of the two counts per cycle. The red bar represents the Aluminum contamination in sample 2 throughout the experiment. The width was determined from the highest to the lowest amount of Aluminum contamination gathered using energy dispersive x-rays.

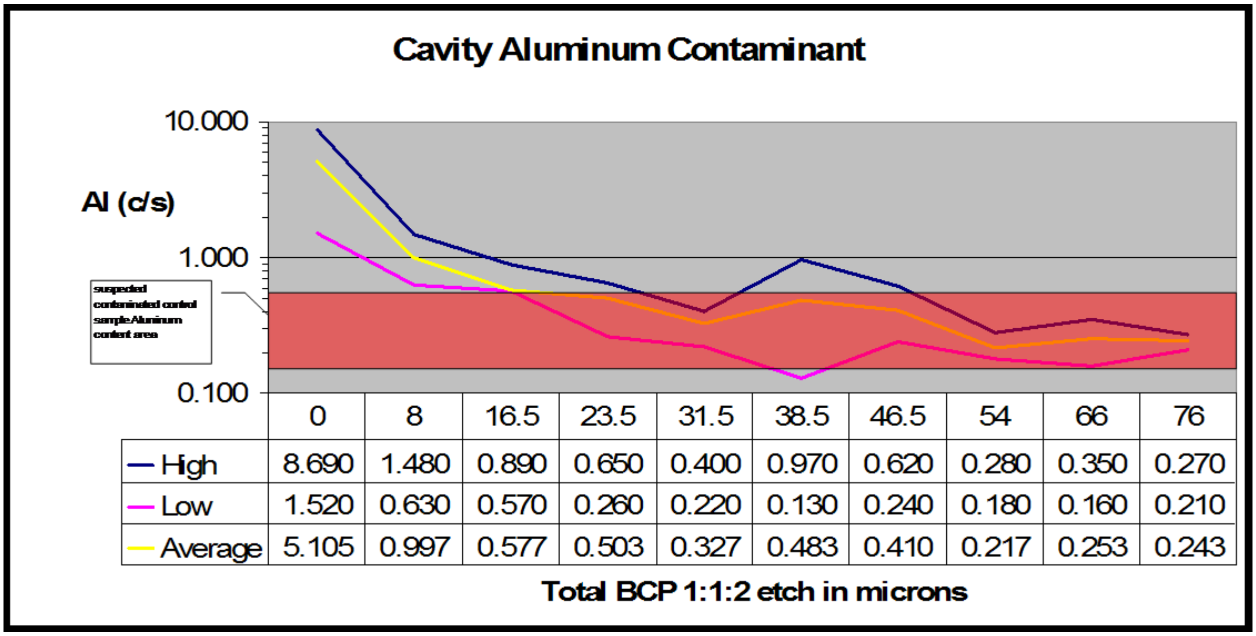

FIG. 2: the depth profile of Aluminum contamination in sample 1. The red area is representative of the background aluminum signal, measured from sample 2.

III. CONCLUSIONS

Tumbling niobium with Aluminum oxide rocks results in contamination in the form of aluminum oxide particulates/clusters. The concentration of contamination decreases exponentially with the depth initially. At a depth of about 20-30μm, it begins to reach the detection limit. It is concluded that the minimum etching required to remove the contamination layer is approximately 30μm

IV. ACKNOWLEDGMENTS

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