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Analysis of
"Beryllium" Speaker Dome and Cone
Obtained from China

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Scanning Electron Microscopy Evaluation of Speaker Dome Material for a 1 inch Cone and 4 ½ inch Cone

Background

Domes for a 1 inch cone and 4 ½ inch cone were provided by Christopher Dorn with an initial request to determine the dome material. Both cones had what appeared to be paint flaking off. Using Energy Dispersive Xray Analysis (EDXA) both cones were determined to be titanium. This result led to request for additional information, including a request to determine if beryllium was present.

The R&D laboratory Electron Spectroscopy for Chemical Analysis (ESCA) unit would have the ability to evaluate coating, however it is not operational at this time or the foreseeable future.

Technical Approach

Scanning Electron Microscopy (SEM) with backscatter electron imaging (BEI) and EDXA were used to evaluate the material. This particular unit is capable of detecting beryllium, however, the beryllium must be about 90 atomic percent. Beryllium peaks have been observed in titanium beryllide and calcium beryllide. Only oxygen is detected when BeO is analyzed. Beryllium can be inferred based on the SEM images and especially EB images owing to its very low atomic weight.

In order to determine the material of the cone, the cross sections were mounted and polished. This avoided any possibility of error caused by the coating (paint?). To evaluate the coated surfaces of the domes, small pieces were cut and secured by carbon tape to the stage.

Results

1 inch Dome

The material for the 1" speaker dome was determined to be titanium based on cross section (Figure 1) EDXA results (Figure 2). No microstructural features were apparent in the cross section.

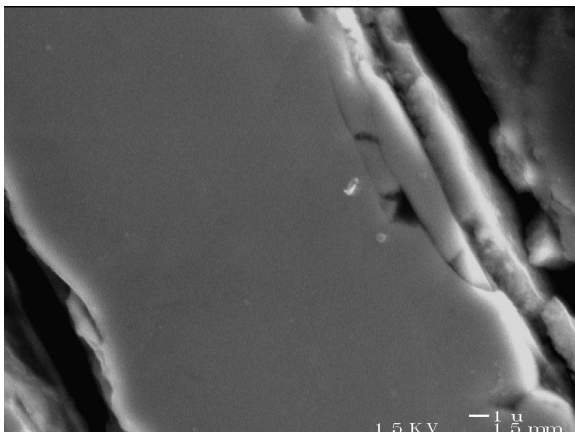


Figure 1 SEM Cross Section of 1 inch Dome

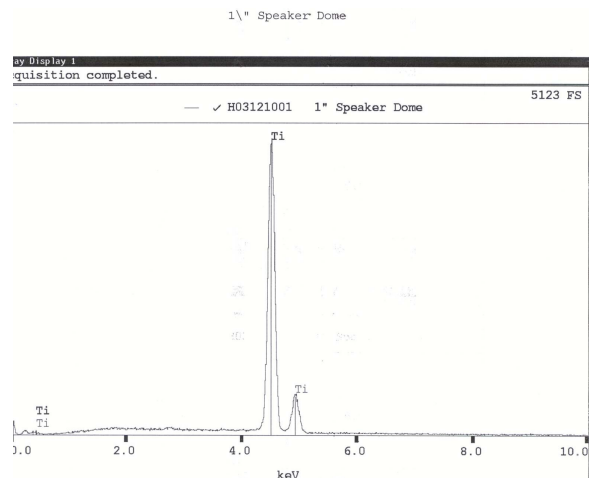


Figure 2 EDXA Spectra of Figure 1 Showing Titanium

The material coating was quite friable and readily spalled off. The SEM image in Figure 3 shows 2 major areas. There is the dark coating that is flaking off and a lighter colored surface that is mottled underneath. EDXA spectra using 10 kV beam voltage shows only titanium peaks for both areas (Figure 4). The beam voltage was reduced to 5 kV to detect materials at the surface. Spectra for the dark area, the light regions of the light mottled area as well as the dark areas in the light mottled area shows carbon, oxygen and nitrogen. Titanium was not detecting owing to the low beam voltage. The dark coated area had very high oxygen content suggesting the coating was a paint containing oxide (probably TiO_2) as opaquing agent (Top Figure 5). The spectra for the light area of the light mottled area had the lowest signal to noise ratio suggesting this was the "metal surface" (Middle Figure 5). These results are indicative of titanium being a strong oxide, carbide and nitride former. The dark areas of the mottled area appear to be different that the coat surface, although both areas have high oxygen peaks (Top and Bottom Figure 5). The oxygen to carbon ratio appears to be different for the two spectra.

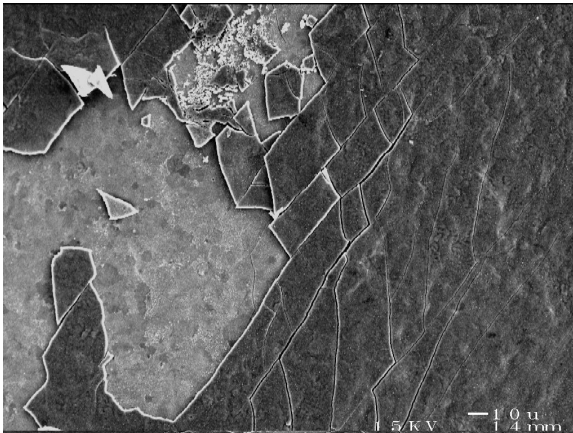


Figure 3 SEM image of 1 inch cone surface showing flaking coating and under laying material.

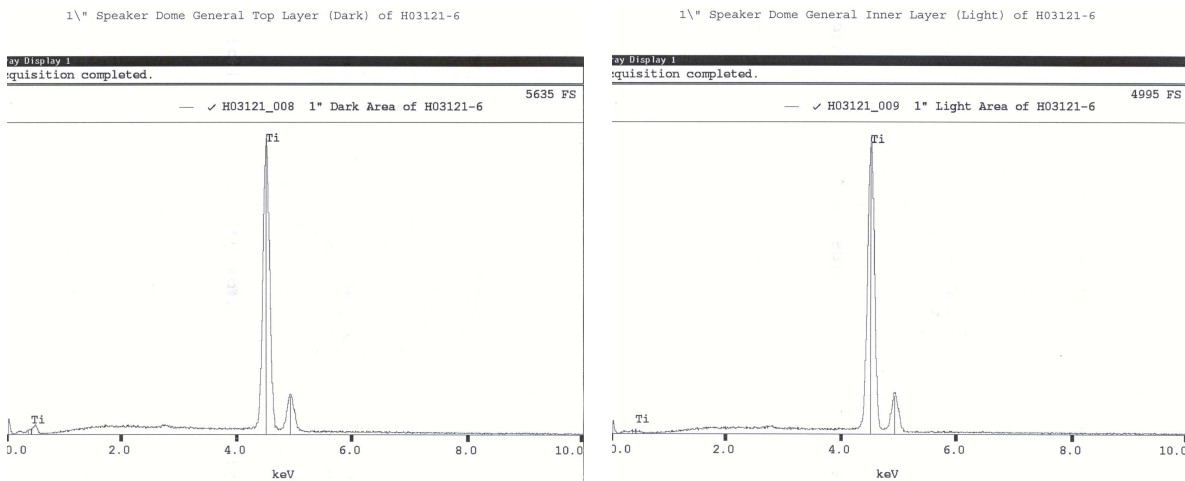
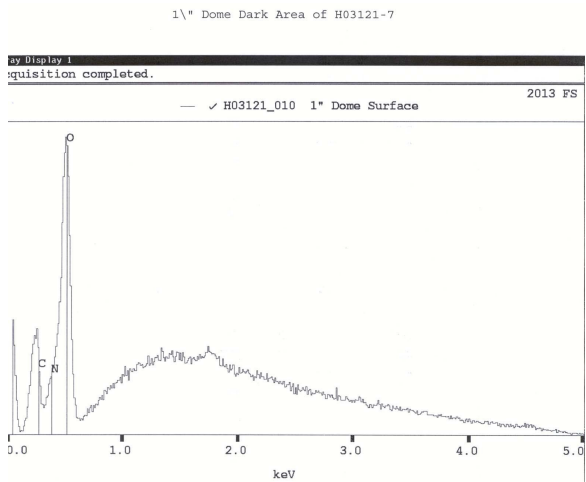
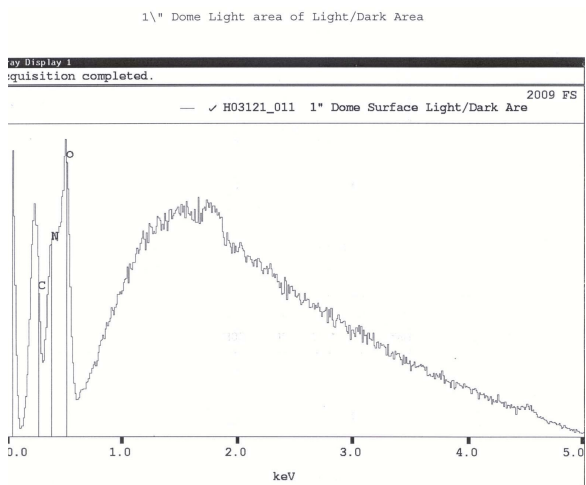


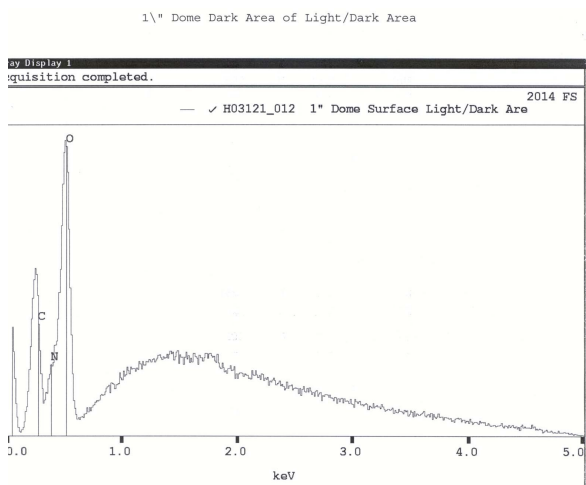
Figure 4 EDXA Spectra Showing Titanium at 10 kV Beam Voltage for Both the Dark Coated Surface and the Light Mottled Surface in Figure 3



Dark area of Figure 3 showing high oxygen content



Light area of the Light Mottled Area in Figure 3



Dark area of the light mottled area in Figure 3

Figure 5 EDXA Spectra for dark coated area, the light area on the mottle surface and the dark area on the mottled surface

4 ½ inch Dome

Microstructural features are shown in Figure 6 for the polished cross section of the 4 ½ inch dome. The two outer layers appear featureless while grain structure is apparent in the middle. The “color” of all of the cross section suggests all area have a very similar atomic weight and are very likely to be the same material. Cracks only appear to be contained only in the featureless outer layers.

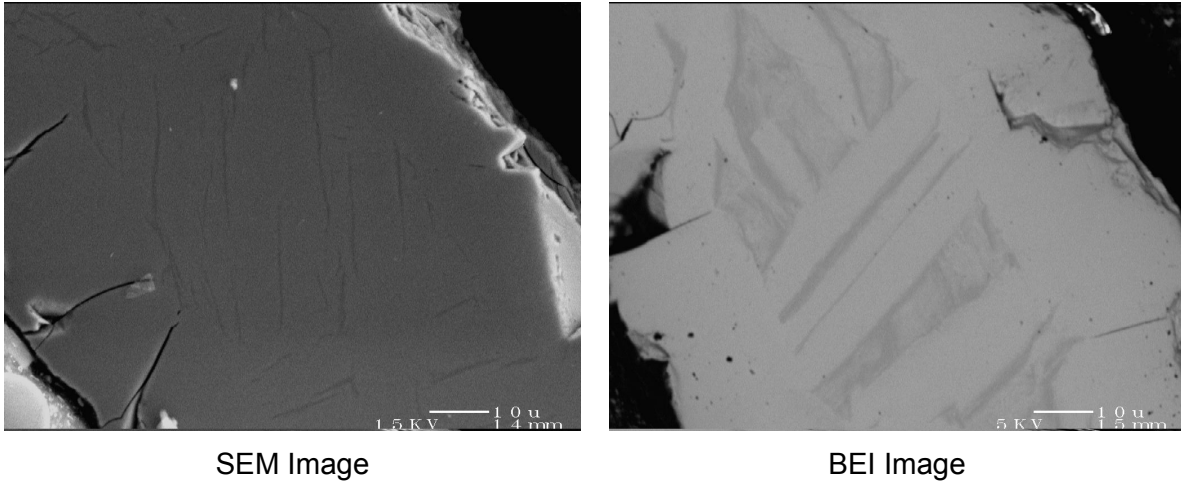
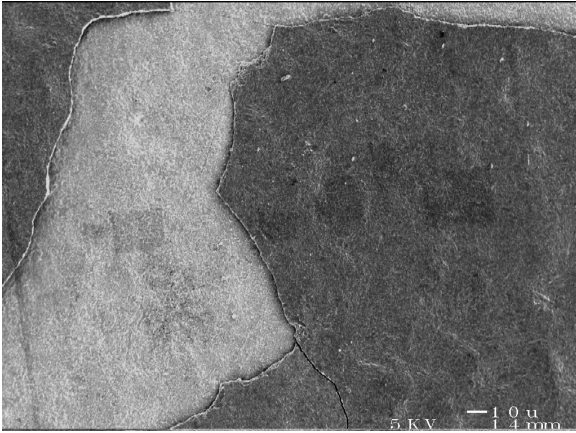
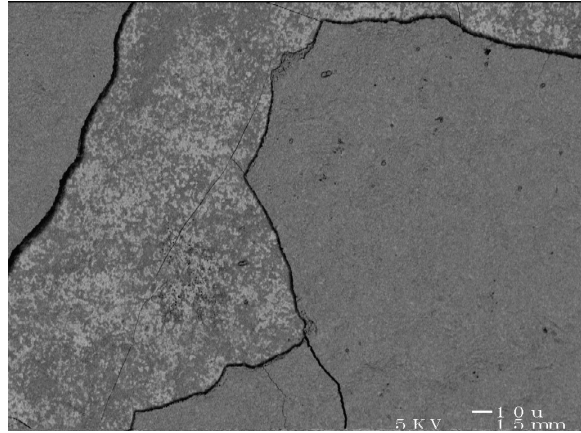


Figure 6 4 ½ inch Dome Cross Section Images

The ESCA results and surface examination results for the 4 ½ inch dome were very similar to the 1 inch dome. The surface showed a dark flaking area with a lighter colored mottled area (Figure 7I). The base material was determined to be titanium for the cross section and surface using 10 kV beam (Figure 8). Carbon, oxygen and nitrogen could be seen using a 5 kV beam (Figure 9). The carbon peak was higher for the 4 ½ inch dome light mottled area compared to the 1 inch dome.

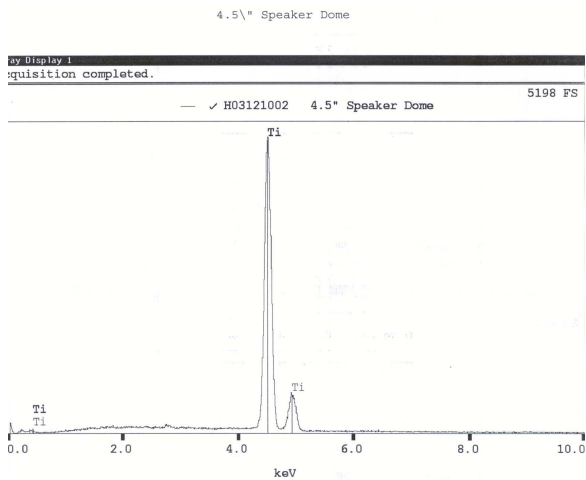


SEM Image

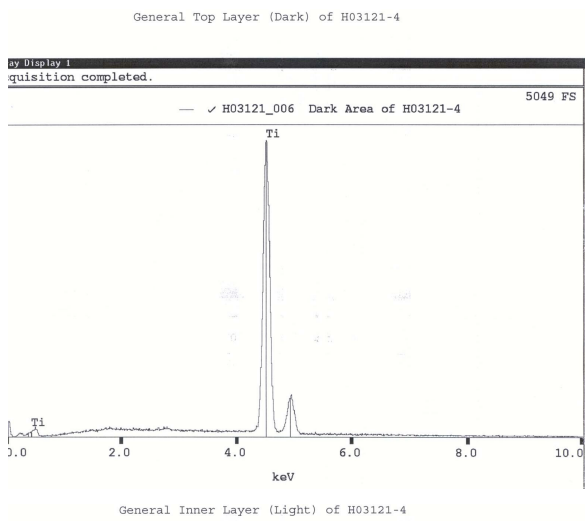


BEI Image

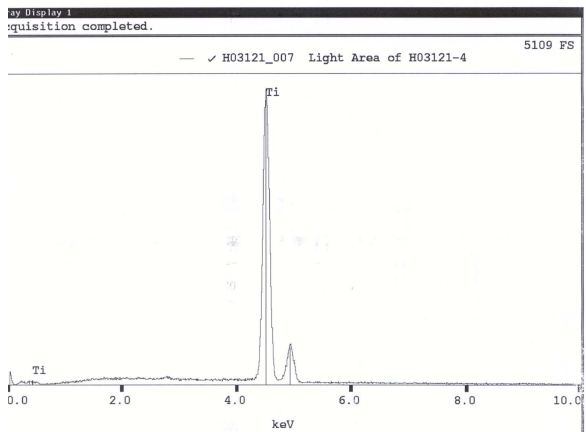
Figure 7 SEM and BEI images for 4 ½ inch dome showing similar features to 1 inch dome.



EDXA Spectra of Cross Section

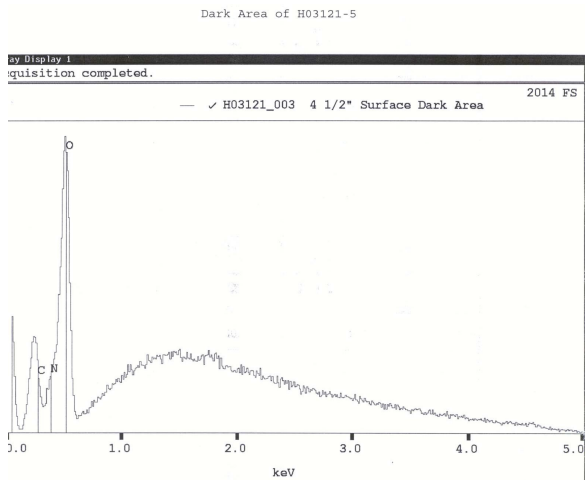


EDXA Spectra of Dark Surface Area

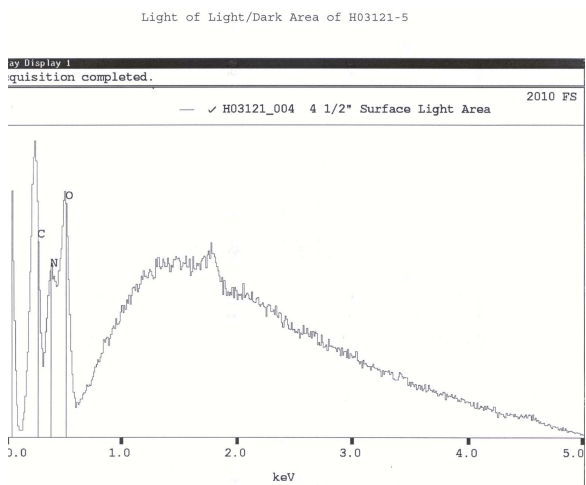


EDXA Spectra of Light Surface Area

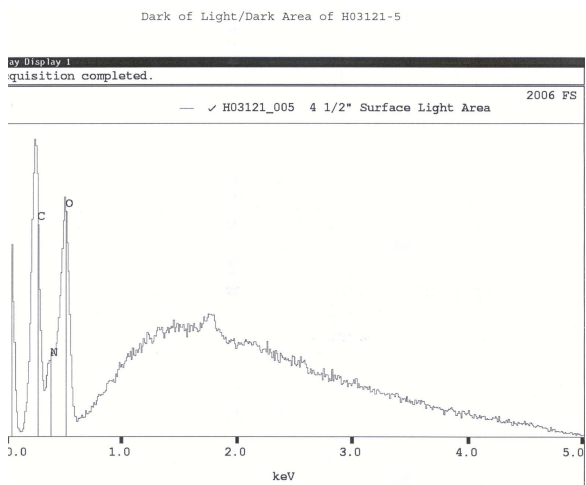
Figure 8 EDXA Spectra (10 kV beam) for 4 ½ inch Dome



Dark Area



Light Area of the Light Mottled Area



Dark Area of the Light Mottled Area

Figure 9 EDXA Spectra (5 kV beam) for 4 1/2 inch Dome

Summary

Both domes are titanium.

No evidence of beryllium could be discerned based on EDXA, SEM or BFI images.