Cross Sectioning Small Hole Arrays using the Model 590

SBT
Sample Preparation

1.0: Purpose

The purpose of this report is to develop and outline a specimen preparation process designed for producing cross sections of small devices which contain arrays of holes throughout the center of the structure. These devices are coated with various thin film materials and the cross section of the devices should show the coating uniformity throughout the hole as well as preserve the integrity and coating uniformity during processing. Development of preparation protocols will be done to successfully prepare these cross sections.

2.0: Materials and Methods

Several steps were involved in preparing these specimens for cross section viewing. The devices were first cut along a specific orientation to allow a full row of holes to be nearly parallel to the cutting edge. Cutting was done using a Model 850 wire saw. The wire saw offers several advantages to traditional diamond wheel sawing, primarily low damage and abrasive selectivity. The size of the abrasive used during the cutting process is variable, providing a smooth cut surface which reduces polishing process steps necessary for producing a good cross section. The Model 850 also offers the advantage of precise alignment of the cutting wire relative to the specimen orientation prior to sectioning, again further reducing processing times during polishing and allowing for selected areas to be sectioned. Following cutting, specimens were attached to the Model 590 Tripod Polisher ™ and then polished using abrasive lapping films on a Model 920 Lapping and Polishing machine. Samples were viewed both in plan view and cross section during processing to ensure that the center of the holes were reached on the final polishing step.

Specimen Configuration

Two different specimen configurations were used for processing. Individual diaphragm devices which contained the small hole arrays, and the complete assembly of the generator. Both are shown schematically below:

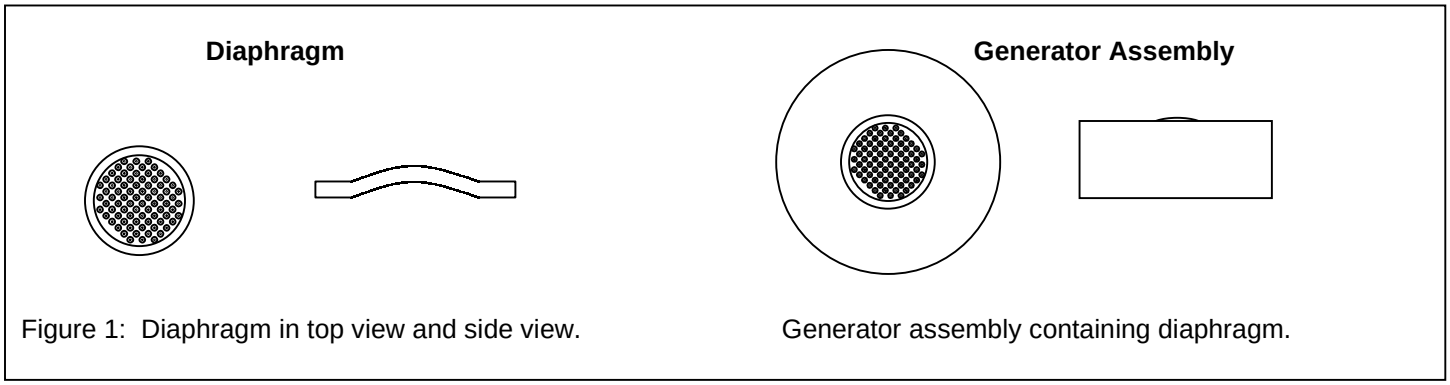

Figure 1: Diaphragm in top view and side view.

Generator assembly containing diaphragm.

Diaphragm Processing

The individual diaphragm samples were initially mounted directly to the Model 590 Tripod and polished using diamond lapping films. Specimens were first ground using 320 grit SiC abrasive paper to thin the disc diameter into an area of the hole arrays. Following this process, the holes were aligned to the progressing polishing plane using the Model 590 and were then polished with progressively finer diamond lapping films, which included: 30, 15, 3, 1, and 0.5 μm films. Final polishing was done using a Multitex polishing cloth and 0.05 μm colloidal silica. This process however did not yield the desired results. The initial cross section of the diaphragm appeared smooth and uniform, however the coating of interest appeared to lift off during the polishing process. The process was then modified to first encapsulate the diaphragm between two glass plates using low melting point wax. The entire assembly was then cut using the Model 850 wire saw parallel to the hole arrays followed by polishing using

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the Model 590 as with the first process. This yielded improved results with a thin coating layer apparent on the specimen, indicating a better quality polish. Below is a diagram illustrating the specimen configuration as it was prepared using the technique described.

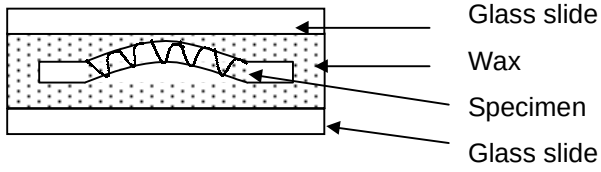

Figure 2: Schematic illustration of the diaphragm specimen assembly used for polishing the cross section. The specimen is stacked between two glass slides and filled in with an acetone soluble, low melting point wax. The wax protects the thin film coatings and the glass slides provide support to the assembly.

Generator Processing

The same type of process was carried out for the generator systems which contained the diaphragm mounted into a small aluminum cup. Initially, these were first cut using the Model 850 wire saw for making a cross section cut through the center of the assembly, creating two specimens for polishing in cross section. This process also aligned the array of holes for polishing without the need for excessive corrections in the polishing plane. Cutting took less than 1 minute and produced a nice clean edge. These samples were then mounted onto the Model 590 and polished as with the diaphragm specimens. Again, the problem of thin film lift off and removal appeared and the need for encapsulating the assemblies during polishing was necessary. This was accomplished through a two step cutting process in which the assemblies were first cross sectioned and the cut parallel to the diaphragm to produce a flat sample containing the diaphragm assembly. These were then mounted between two glass plates with wax and polished, similar to Figure 2. Below is an illustration demonstrating this process.

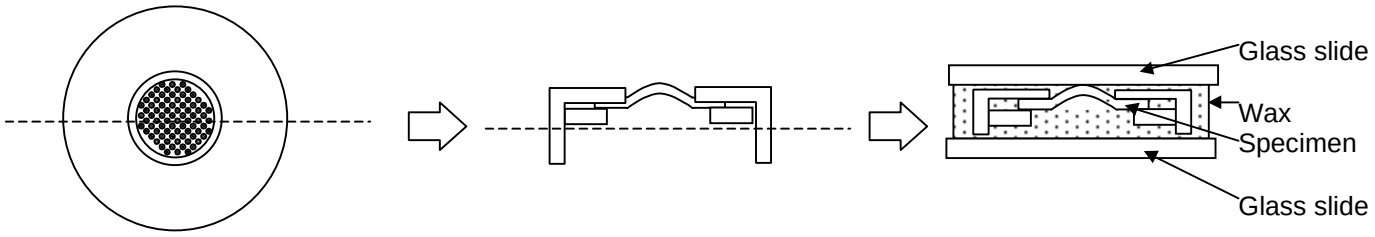

Figure 3: Illustration of the process used for preparing the generator assemblies. The generator is first cut into a cross section across the hole arrays with the cut parallel to a row of holes. Next, the assembly is cut parallel to the array to create a relatively flat specimen. Finally, the assembly is mounted between glass plates with low melting point wax to protect the fragile thin film coating. The entire assembly is then polished to the desired cross section.

3.0: Results

Some observations were made in regards to the samples following the preparation. Cutting the samples with the Model 850 wire saw prior to polishing the cross section offered a distinct advantage over polishing to the area of interest without cutting. The Model 850 allowed 2 grinding steps to be removed from the process, and the integrity of the thin film coating following cutting was excellent. Cutting with the wire saw also allowed precise alignment of the cutting plane relative to the array of holes for cross sectioning, and therefore made the polishing process much more efficient. Only slight adjustments were necessary to get the samples in the desired orientation for cross section, and also increased the amount of holes per sample which were cross sectioned.

Several different abrasive types were used to find the best possible surface finish and removal rates. Aluminum oxide, silicon carbide, and diamond abrasive lapping films all were used for polishing the cross sections. The best results were

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the diamond films, exhibiting good lifetime, high removal rates, and extremely good surface finishes necessary for good optical inspection. The diamond films also preserved the thin films better than any of the other abrasives mentioned. For polishing the cross sections, the total time it took ranged from 1 hour for basic diaphragm sections to 2 hours for the generators. However, the most time consuming portion is the location of the holes and aligning the cross section properly to hit the center. This is made trivial using the Model 590, since both the plan view and cross section can be evaluated during processing, and adjustments can be made to the tool until the polishing plane matches the array plane of the holes.

Final polishing of these samples produced relatively smooth surfaces, but the wax layer may act as a carrier to some abrasive metal particles from earlier coarse grinding steps. A harder material such as epoxy or super glue may be a better substitute for the filler material. However, the wax layer is easy to adhere, is easy to clean, is transparent for visual inspection, and temporary. This makes it an attractive choice for using it as the adhesive layer.

Total processing times for both specimen types were relatively short compared to other techniques used, and with the increased precision and control of the cross section should be an excellent method for preparing specimens of this type.

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