

A Simple Mounting Technique Ensures Exact Measurements of Opaque Coatings

Measuring the thickness of inorganic coatings or paint on metallic surfaces on metallographically prepared specimens is difficult because the opacity of the coating blends into the mounting medium, and a sharp, well defined interface at the outer surface of the coating and the mounting medium is hard to see.

The mounting technique described herein will ensure a well-defined interface and, at the same time, eliminate rounded edges associated with polishing procedures. As an added benefit with this technique, an accurate taper magnification can be determined without performing the exacting procedures associated with taper mounting.

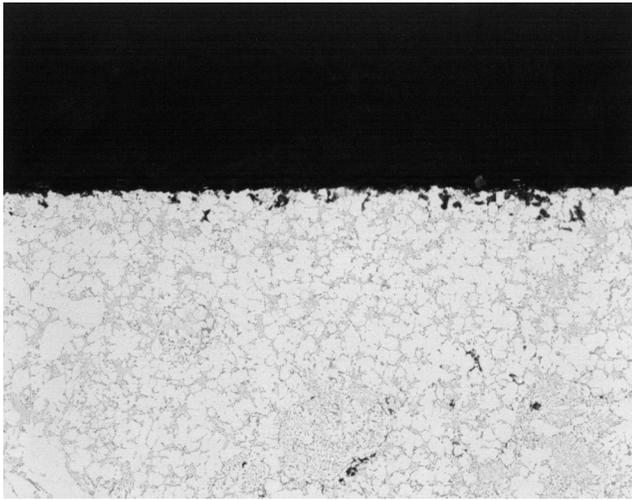
Aluminum Foil Technique for Opaque Coatings And Paint Layers

Suitable sections are obtained by normal sectioning procedures and the parts deburred, cleaned, and dried. Prior to mounting, each section is wrapped separately in aluminum foil and molded to the part with the fingers, taking care that the foil is not punctured. Only one layer of aluminum foil is required, and folds and laps should be located above the plane of polish. Compression mounting should be used, as the pressure will mold the foil tightly to the exact contour of the coating. Conventional techniques for holding thin specimens on edge can be used. Normal mounting procedures are used; however, it is recommended that the mount be cooled under pressure to almost ambient temperature to eliminate edge separation. Mounted samples are prepared using normal metallographic techniques.

Figure 1 is an anodized aluminum sample prepared with and without the foil technique. The mounting medium is red bakelite. Grinding was performed using a traditional silicon carbide grinding sequence, followed by an intermediate polish with 1-micron diamond compound impregnated on a red felt cloth with oil as a lubricant, then final polished with a magnesium oxide slurry on a medium nap cloth. The anodized layer-mounting medium interface is difficult to see in Figure 1(a); however, in Figure 1(b) the foil technique gives excellent delineation of the anodized layer.

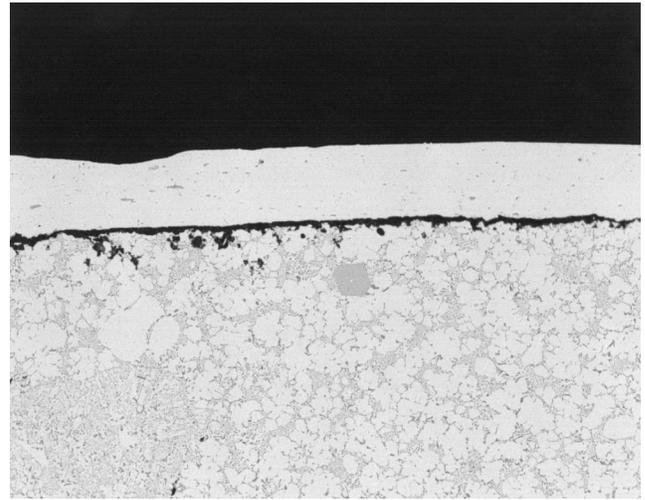
Figure 2 shows an epoxy paint on a low carbon steel substrate. The mounting medium is red bakelite and normal grinding and polishing procedures were employed. The paint-mounting medium interface is extremely difficult to see in Figure 2(a), but when the foil technique is used as shown in Figure 2(b), there is no difficulty in seeing the thickness of the paint layer.

The aluminum foil not only serves to give excellent definition to the coating edge, but also prevents rounding of the edges during polishing, despite the softness of the aluminum foil. Moreover, the black lines on the scale in a measuring eyepiece will be quite visible on both sides of the coating and not blend into the dark mounting medium if the foil were not present.



As-Polished 800X

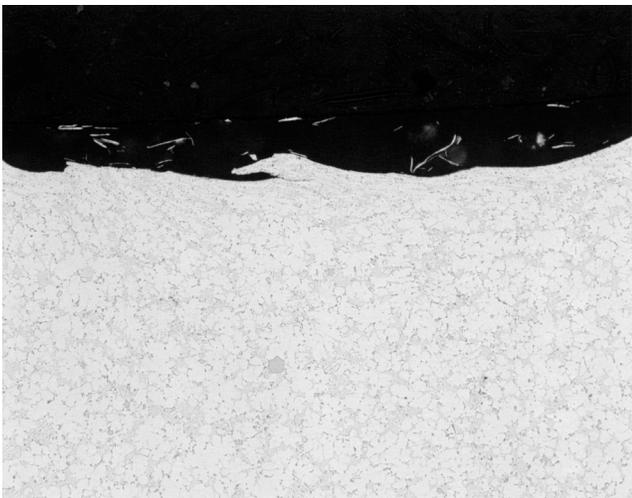
(a) Without Aluminum Foil



As-Polished 800X

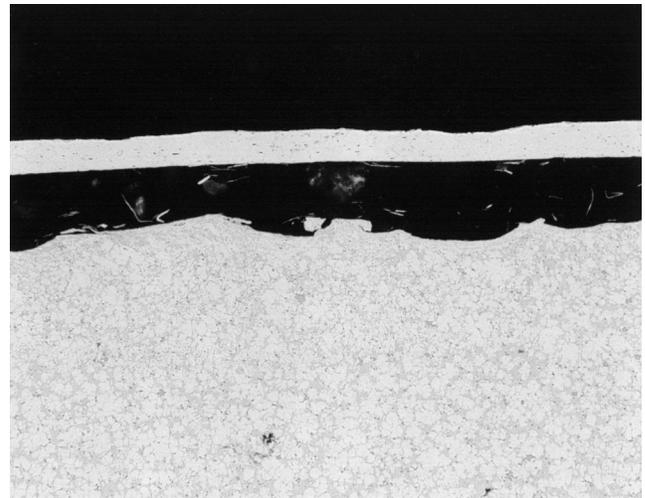
(b) With Aluminum Foil

Figure 1. Anodized aluminum specimens prepared with and without aluminum foil.



As-Polished 400X

(a) Without Aluminum Foil



As-Polished 400X

(b) With Aluminum Foil

Figure 2. Epoxy paint on steel specimens prepared with and without aluminum foil.

Aluminum Foil Techniques Used for Determining a Taper Magnification

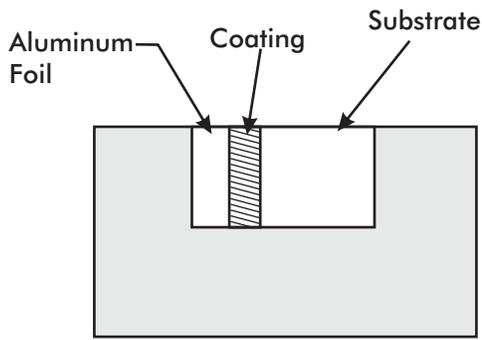
Taper sectioning (taper mounting) is a special technique employed when the thickness of a coating (metallic or inorganic) is so extremely thin that it is impossible to resolve the coating even at the highest magnifications obtainable with optical microscopes or metallographs. Briefly, this technique is polishing a sample at an angle to the normal polishing plane. The angle is important and is predetermined by placing shims of known heights at specified distances from the end of the sample to be polished. The sample is cut to a length of at least 1.0 inch, mounted with the coated side facing the bottom of the mold, and a shim is placed at one end. Castable mounting media is required. The height of the shim and the distance the shim is placed from the end of the sample determines the taper magnification. For example, a 0.1 inch thick shim placed 1.0 inch from the end of a sample will result in a 10X taper magnification; the angle of taper is $5^{\circ} 43'$. Since the taper magnification is predetermined before any metallographic procedures are employed, it has to be assumed that the taper magnification remains true throughout the grinding and polishing steps; i.e., the shim has not moved due to the curing stresses set up when the castable begins to harden, and the final polished surface is absolutely parallel to the back surface of the mount. The slightest deviation from parallelism will change the angle of taper and the taper magnification, thus creating errors in coating thickness measurements.

When the taper mount is prepared, the thin coating will be broader than the actual thickness, and when measuring the width of this broadened layer, the total magnification is used; i.e., the actual magnification used times the taper magnification. For example, if microscopic examination is being conducted at 400 diameters and the taper mount has been prepared with a 10X taper magnification, the total magnification will be 4000X (400x10). This total magnification must be used when measuring coatings on tapered mounts.

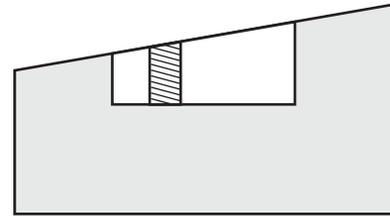
It is difficult to maintain absolute parallelism between the polished surface and the back of a mount when manually preparing samples. Invariably, a mount will be prepared with a slight tapering effect because of unequal pressures applied during the grinding steps. Normally this will not affect the study of microstructures, but if the specimen has a thin coating which is to be measured microscopically, a tapered mount will give erroneous thickness measurements because of the taper magnification which is present but not taken into consideration.

Using the aluminum foil technique, an immediate and accurate taper magnification can be determined on even the slightest tapered mount by knowing the thickness of the aluminum foil used; and the thickness of the foil after polishing the specimen.

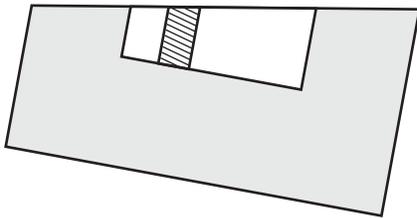
The thickness of the aluminum foil is determined by hand-held micrometers. When the polished taper mount is examined microscopically, the thickness of the aluminum foil is determined by a filar measuring eyepiece. Micrometer discs having a fixed scale (which are inserted into eyepieces), are not recommended because accurate fractional increments cannot be determined. The following illustration shows a normally prepared mount and a mount which has a taper. (The degree of taper is exaggerated for purposes of illustration).



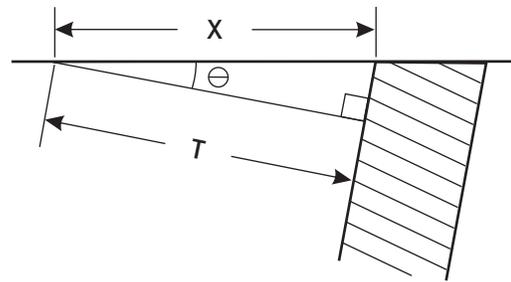
(a) Normal



(b) Ground on a taper



(c) Oriented for microscopic viewing



(d) Expanded view of (c)

Figure 3. Tapered mount and how the aluminum foil technique is used to determine taper magnification.

In Figure 3(d), the original thickness (T) of the aluminum foil is 0.001 inches and 0.00108 inches on the taper (X). The taper magnification is determined as follows.

$$\text{SECANT } \theta = \frac{X}{T} = \frac{0.00108}{0.001} = 1.08 \text{ taper magnification}$$

Let us assume a mount has been made containing two sections of a specimen with a thin coating. One specimen has been wrapped in 0.001 inch thick aluminum foil and the other specimen has not. The mount is prepared manually, and the coating on both specimens measures 0.00006 inches at 1000 diameters. However, when the aluminum foil is measured on the foil wrapped specimen, the foil measures 0.0015 inches. Following the preceding exercise, secant \ominus (0.0015 divided by 0.001) equals 1.5X taper magnification, and the total magnification is 1000x1.5 or 1500 diameters. Therefore, the thickness measurements were made at 1500 diameters, not 1000, and the 0.00006 inch measurement is not correct. The actual thickness of the coating is 0.00004 inches (measured thickness, 0.00006 inches, divided by taper magnification, 1.5X).

Aluminum Foil Technique for Gold Plated Surfaces

Measuring the thickness of gold which has been deposited on a metallic substrate can be difficult because the gold will smear very easily; also, regardless of how carefully the specimen is prepared, edge rounding will occur. Mounting the sample wrapped in aluminum foil has the advantage of placing a known thickness against the layer to be measured and also serves as an absolute gauge for determining if smearing or rounding of the gold layer has occurred.

Aluminum Foil Technique Used with Scanning Electron Microscope (SEM) Studies of Wear Surfaces

Characterization of wear surfaces is usually done with an SEM, with a separate metallographic preparation on a cross-section through the wear area to correlate wear with microstructural differences.

Using the aluminum foil technique, both the wear surface and the microstructure can be examined on an SEM at the same time.

The part to be examined on an SEM is sectioned near the wear area to be studied. If the wear area is prevalent over most of the surface, orientation need not be maintained; however, if the wear area is localized, orientation must be kept. The piece is encapsulated in aluminum foil and mounted in a compression mounting media. Placing a rivet or some other reference piece in the mount on the side near a localized wear area will maintain orientation. A bevel is ground on the mount with the thinner part of the

mount being the referenced area. Polishing and etching follow normal procedures for that particular alloy. After metallographic preparation has been completed, the part is broken out of the mount, making sure to protect the polished surface. The aluminum foil acts as a barrier between the surface of the piece and the mounting medium and will peel away very easily. Following is an illustration of a rod prepared in the manner described.

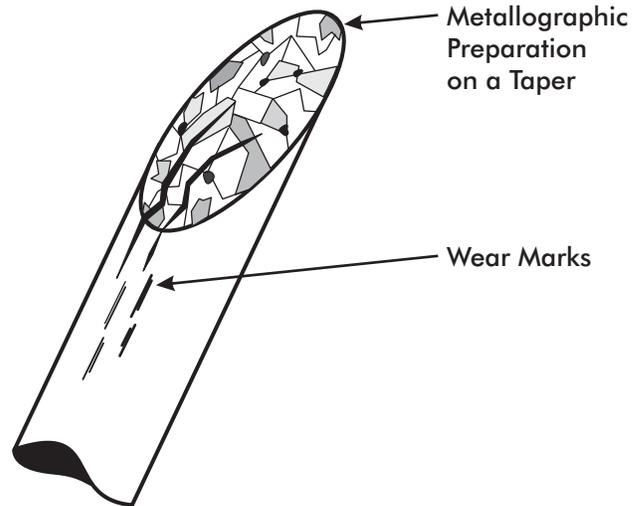


Figure 4. Rod Prepared on a Taper for SEM Viewing Using the Aluminum Foil Technique.

The part is placed into an SEM and tilted for examination of the wear area, and the polished and etched surface. The great focusing depth capability of an SEM allows simultaneous examination at the junction of both areas, and a direct correlation can be made of wear area to the microstructure.

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