Application Notes

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Cleaning and Handling Recommendations

The following procedure for cleaning ITO and ATO should only be performed while wearing appropriate safety apparel and eye protection, in a fume hood, under the supervision of a qualified chemist.

Even with careful handling of the transparent conductive coated products which we supply, we cannot guarantee them to be contaminant-free. When handling glass products in our facilities, we use powder-free non-latex gloves, which in turn are covered by nylon or polyester gloves to prevent transferring finger oils to the coated surfaces. Parts are packaged with paper slips between to prevent them from rubbing against each other and possibly damaging the ITO coating. Over time, organic contaminants may adsorb onto the metal oxide coating, and cleaning becomes necessary.

To clean ITO and ATO products, we recommend using a 20% by weight solution of ethanolamine in deionized water, heated to 80 °C in an ultrasonic bath, within an approved fume hood. Immersion of parts in this solution with ultrasonic agitation for a period of 10 to 15 minutes is an efficient method for the removal of any fingerprints, body oils or similar residual organic contaminants. The solution is moderately caustic. Solution vapors can irritate mucous membranes and can cause burns, and should be avoided. Following the immersion cycle, the substrates should be removed and rinsed several times with deionized water, and finally blown dry with a clean, oil-free nitrogen or air source to avoid water spotting.

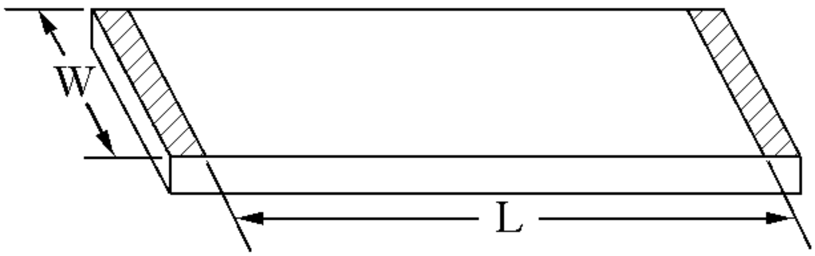
Alternate methods of cleaning include the use of solvent cleaning solutions in conjunction with deionized water rinses, and the use of vapor degreasing systems.

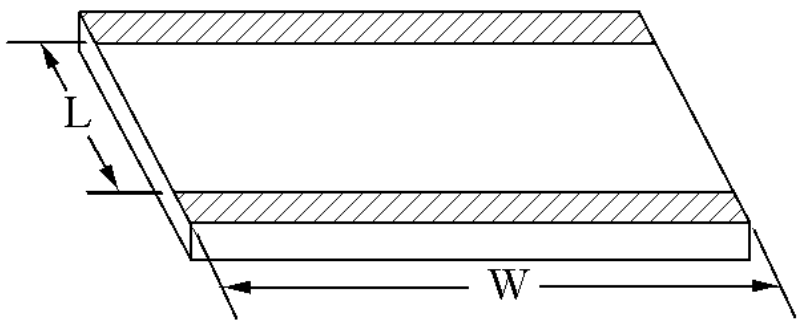
Measuring Electrical Characteristics

We're occasionally asked about the "resistance" of the transparent conductive products we offer. The resistance of these transparent, conductive, thin film products is measured according to methods outlined in ASTM D 257 - 93, "DC Resistance or Conductance of Insulating Materials." A thin film's electrical property is generally characterized as surface resistance, Rs, which is the ratio of the dc voltage applied to two electrodes on the surface of the sample to the current between them. Since the effect of volume resistance is negligible, it is typically ignored in films as thin as these. The surface conductivity is the reciprocal of the surface resistivity. Surface resistivity, Ps, is the surface resistance, Rs, multiplied by the ratio of specimen surface dimensions (width of two parallel electrodes defining the current path divided by the distance between them) which converts the measured resistance into a value that would be obtained if the electrodes formed two opposing sides of a square. While specific resistance is quantified in ohms, it is frequently referred to in "ohms/square." In this context, the size of the square is immaterial and without dimension. The formula

Ps = Rs x W / L {P represents the greek letter, rho} where Rs is the indicated resistance, W is the length of each of the electrodes, and L is distance between them. Current will flow from one electrode to the other. Assuming Rs for the example is 80 ohms, and that L = 2W (immediately below), we would calculate that

Ps = Rs x W / L = 80 ohms x W / 2 W = 80 ohms / 2 = 40 ohms.





In comparison, measuring in the other direction (immediately above), our ohmmeter should indicate Rs = 20 . Since we know that Ps is a ratio of the electrode length to the distance between (and that the ratio for our example is now W = 2 L), we would correctly calculate the surface resistivity:

Ps = Rs x W / L = 20 ohms x 2 L / L = 20 ohms x 2 = 40 ohms

(Note that the dimensions for L and W cancel, regardless of the size of the sample or units of measure, hence the dimensionless "ohms per square".)

Due to the morphological variability of these coatings, resistance will not be isotropic, and measurable differences will be observed based upon the orientation of the electrodes with respect to the coating. Since it is not always practical to apply conductive bus materials to the thin film coating to make these measurements, the probes of a digital volt meter, DVM, may be used to assess the relative resistance of the coating, or simply to determine which side is coated. Since this kind of measurement will include "fringing" effects, and will typically include a significant contact resistance, you should expect to find a resistance deviation of up to several times higher than if you were to perform the measurement as described above.

To avoid damaging the thin film coating when determining which side is coated, **lightly** touch the barrels of the probes to the same surface of a single-side coated product. Testing the alternate side will quickly show one with a low resistance as compared to the opposing side, which will exhibit an essentially infinite resistance.

Patterning ITO Coatings

The following procedure for etching ITO should only be performed while wearing appropriate safety apparel and eye protection, in an approved fume hood, under the supervision of a qualified chemist.

An aqueous solution of 20% HCl, 5% HNO3, plus a few drops of liquid detergent to promote wetting the ITO surface, is efficient in removing ITO. This solution should be mixed in an acid-resistant container in a fume hood that is certified for evacuation of acidic fumes. Use of this solution heated to 55 °C will typically etch 100 ohm ITO coatings in 30 to 60 seconds. Since there is some variability in the morphology of the coatings, and more conductive coatings will be thicker, this will affect the time required to complete the removal of the ITO. If etching is carried out in a room temperature solution of the etchant, etching of a 100 ohm coating will take from six to ten minutes. Changes in the purity or concentration of the acid solution as it is consumed by repeated etching will similarly affect the etch rate. It is important to remember that all ITO coatings are readily attacked by mineral acids and strong organic acids, and direct exposure to such agents risks loss of the coating.

Upon completing the etching process, the substrates should immediately be rinsed in a 10% aqueous solution of Na2CO3 to neutralize any acid remaining on the coated surface. Any subsequent process to remove resist used for generating patterns in the coating should be followed by a cleaning process, a series of deionized water rinses, and finally blowing dry with a clean, oil-free nitrogen or air source. This final step is important to avoid water-spotting, which may have unforeseen effects on any subsequent use of the etched coating.

In conjunction with an appropriate photo/screen resist, this procedure may be used to generate patterns in the ITO coating. We have found in our experience with both positive- and negative-acting photoresist chemistries, that adhesion of the resist to the ITO surface is best when applied to recently cleaned ITO substrates which have been subsequently baked for 30 minutes at 175 °C within 30 minutes prior to resist application. Heating the substrates in this fashion reduces the presence of moisture on the surface of the substrate, thus providing better adhesion of the photoresist coating. Storage of uncoated ITO in a N2 purged dry box will increase the time during which resist may be reliably applied to the ITO surface. In all cases, follow the directions of the manufacturer of the resist product being utilized to insure proper curing of the coating prior to exposure to the etching solution.

We do not recommend trying to etch the ATO coating. However, if etching this coating is a necessary part of your plans, please contact us regarding methods for its removal.

Lead Attachment / Electrical Contacts

Establishing good electrical contact with the conductive film is essential, in order to best utilize its properties. Unlike metal foils or meshes, an ITO or ATO coating is only 200 Å to 2,000 Å thick, and point-of-contact probes, or devices such as alligator clips may tend to cut through the coating rather than embed into it, as they would in a metal sheet or foil. This produces a high resistance contact, which will limit the current that can be carried by the coating and may also effect a significant voltage drop.

Two better methods for attachment of leads involve the use of highly conductive silver bus compositions. These can be applied to the ITO or ATO surface along an edge, for example, and dried or cured, depending on whether the composition is a thermoplastic or thermoset material. The resulting bus bar provides a highly conductive layer in intimate contact with the transparent conductor. The attachment of an alligator clip to the bus bar, while it may penetrate the transparent conductor, will also make excellent contact with the bus material. Since the bus material is several orders of magnitude (from 3 to 5) more conductive than the transparent semiconductor, contact resistance is minimized and any voltage drop a this interface becomes negligible.

An alternate method of attaching leads to the coatings also uses a conductive silver bus composition, but in combination with fine wire (copper, silver, gold, platinum) imbedded in the bus material before it is dried/cured. With careful handling, this method is very effective. Care must be exercised in manipulating the wire, once attached. One good method to employ is to wind a number of turns of the wire around a pencil or rod of similar diameter, creating a helical "spring" to take the stresses of subsequent handling of the wire as it is attached to a current source. Should the lead break loose, it can be re-attached with an additional droplet of bus material.