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Standard Practice for Measuring Sheet Resistance of Thin Film Conductors For Flat Panel Display Manufacturing Using a Noncontact Eddy Current Gage[1]

This standard is issued under the fixed designation F1844; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes methods for measuring the sheet electrical resistance of sputtered thin conductive films deposited on large insulating substrates (glass or plastic), used in making flat panel information displays.

1.2 This practice is intended to be used with Test Methods F673. This practice pertains to a "manual" measurement procedure in which an operator positions the measuring head on the test specimen and then personally activates the test apparatus. The resulting test data may be tabulated by the operator, or, alternatively, sent to a computer-based data logging system. Both Methods I and II of Test Methods F673 (paragraphs 3.1 through 3.3.3 of Test Methods F673) are applicable to this practice.

1.3 Sheet resistivity in the range 0.020 to 3000 Ω per square (sheet conductance in the range 3 by 10^{-4} to 50 mhos per square) may be measured by this practice. The sheet resistance is assumed to be uniform in the area being probed.

NOTE 1—Typical manual test units, as described in this practice, measure and report in the units "mhos per square"; this is the inverse of "ohms per square."

1.4 This practice is applicable to flat surfaces only.

1.5 This practice is non-destructive. It may be used on production panels to help assure production uniformity.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F673 Test Methods for Measuring Resistivity of Semiconductor Slices or Sheet Resistance of Semiconductor Films with a Noncontact Eddy-Current Gage (Withdrawn 2003)[3]

3. Summary of Practice

3.1 This practice describes the preferred means of applying Test Methods F673 to measure the electrical sheet resistance of thin films on very large, flat, nonconducting substrates. The substrate, oriented with the conducting thin film up, is placed between the transducers of the eddy current sensor assembly at the point of interest. The test arrangement is illustrated in Fig. 1.

3.2 A typical conductance apparatus is described in detail in a paper by Miller, Robinson, and Wiley.[4] This paper also discusses skin-depth as a function of thickness and resistivity.

3.3 A typical apparatus operates as follows: when a specimen is inserted into the fixed gap between the two parallel sensing elements, or transducers, in a special oscillator circuit, eddy currents are induced in the specimen by the alternating field between the transducers. The current needed to maintain constant voltage in the oscillator is determined internally; this current is a function of the specimen conductance.

3.4 Further details are given in Test Methods F673, paragraphs 3.1 through 3.3.3.

3.5 This practice includes calibration procedures for using NIST Silicon Standard Reference Material[5] to ensure proper operation before testing panels.

[1] This practice is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.17 on Sputter Metallization.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

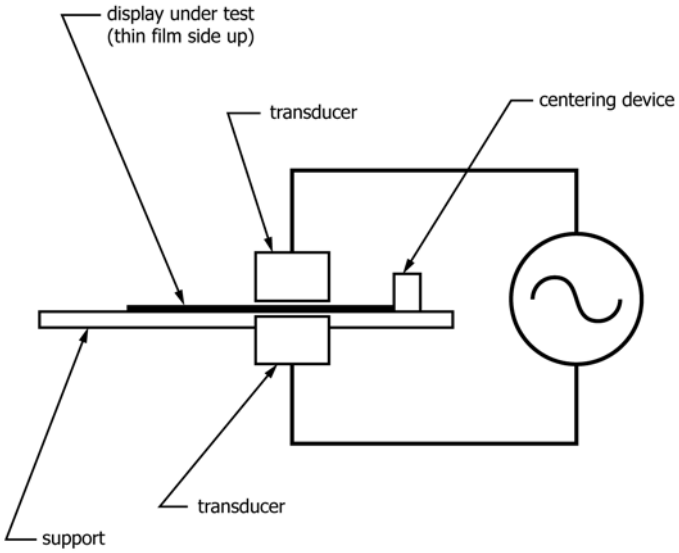
[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Miller, G.L., Robinson, D. A. H., and Wiley, J. D., "Contactless Measurement of Semiconductor Conductivity by Radio Frequency-Free-Carrier Power Absorption," *Review of Scientific Instruments* , Vol 47, No. 7, July 1976.

[5] Available from NIST, 100 Bureau Dr., Stop 3460, Gaithersburg, MD 20899.

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NOTE 1—This figure is partially copied from Fig. 1 of Test Methods F673.

FIG. 1 Schematic Diagram of Eddy-Current Sensor Assembly

4. Significance and Use

4.1 Resistivity is a primary quantity for characterization and specification of coated glass plates used for flat panel displays. Sheet resistance is also a primary quantity for characterization, specification, and monitoring of thin film fabrication processes.

4.2 This practice requires no specimen preparation.

4.3 The eddy current method is non-destructive to the thin film being measured. Special geometrical correction factors, needed for some four-point probe electrical resistivity measurements, are not required to derive the true sheet resistance so long as the transducers have a continuous layer of conductive thin film between them.

4.4 Test Methods F673 refers to a testing arrangement in which the transducers and specimen (a semiconductor grade silicon wafer) are rigidly positioned. Similar apparatus is commercially available for testing large glass or plastic substrates, not envisioned in the scope of Test Methods F673. A hand held probe can also be used, depending on throat depth required.

4.5 For use as a referee method, the probe and measuring apparatus must first be checked and qualified before use by the procedures of Test Methods F673 (9.1.1 through 9.1.3 and 9.1.4.2 through 9.1.4.5), then this practice is used.

4.6 For use as a routine quality assurance method, this practice may be employed with periodic qualifications of probe and measuring apparatus by the procedures of Test Methods F673 (9.1.1 through 9.1.3 and 9.1.4.2 through 9.1.4.5). The parties to the test must agree upon adequate qualification intervals for the test apparatus.

5. Apparatus

5.1 *Eddy Current Sensor Assembly* —See Fig. 1 and Test Methods F673.

5.1.1 Different transducer designs may be required to cover the full range of sheet resistance values.

NOTE 2—Three transducers will generally cover the ranges of interest. For convenience these are denoted “High” (15 to 3000 Ω per square), “Low” (0.2 to 15 Ω per square) and “Extra Low” (0.035 to 0.2 Ω per square).

NOTE 3—The usual “High” range transducer diameter is approximately 12.7 to 15.2 mm. The “Low” and “Extra Low” diameter is approximately 10.1 to 12.7 mm. A very large transducer, 63.5-mm diameter, may be used for all ranges for thicker than normal substrates (up to approximately 2.54 mm) and for calibration and measurement ease.

5.2 *Electrical Measuring Apparatus* —The electrical apparatus must meet the requirements of Test Methods F673, paragraphs 6.1 through 6.4.

5.3 *Specimen Support*— The flat panel to be tested must be supported firmly to ensure that the thin film is parallel with the transducer surfaces.

5.4 *Reagents and Materials* in accordance with Test Methods F673, Section 7.

6. Test Specimen

6.1 The test article shall be a display substrate that has been sputter coated with the conductive thin film of interest or ion implanted and annealed, or made conductive by another process.

6.2 The conductive film must be thick enough that it is continuous. Generally this requires that the film be at least 15-nm thick.

6.3 The area to be tested shall be free of contamination and mechanical damage, but shall not be cleaned or otherwise prepared.

6.4 Note that a sputtered film may also coat the edge of the glass and can coat the back side of the substrate (“overspray”). All overspray, for example, coating on back of glass, must be removed before measurement.

6.4.1 Any remaining overspray will be included in the measurement, lowering the measured film resistivity.

6.4.2 Scribing the substrate near the edge using a glass scribe is not a reliable remedy.

6.4.3 Use a simple 2-point probe ohmmeter to verify that the back side of glass or plastic substrate is insulating.

7. Interferences

7.1 Caution must be taken that the transducer gap is fixed, in accordance with the recommendations of the equipment supplier. This may be ensured by firmly tightening the gap adjustment screws after checking the spacing with gages. Use caution, too, that the electrostatic covers (see Miller, et. al.[4]) are not damaged by the panel under test. The electrostatic cover should be located approximately 0.02 mm below the support surface.

7.2 Radial resistivity variations or other resistivity nonuniformity under the transducer are averaged by this practice in a manner that may be different from that of other types of resistivity or sheet resistance techniques, which are responsive to a finite lateral area. The results may therefore differ from

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