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Standard Practice for Ultrasonic C-Scan Bond Evaluation of Sputtering Target-Backing Plate Assemblies[1]

This standard is issued under the fixed designation F 1512; 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 a method for ultrasonic mapping of the soundness of a bond joining a sputtering target to its supporting backing plate. The results of the examination may be used in predicting the target-backing plate assembly's suitability for use. Accept/reject standards are not specified; these are subject to agreement between target supplier and user, depending upon the application requirements.

1.2 This standard is intended to be used with Practice E 1001.

1.3 The method reveals unbonded areas 0.125 in. (3 mm) in diameter and larger. The technique permits, for example, unambiguous quantitative measurement of the voided area in solder bonds.

1.3.1 This technique may also show regions in which bond integrity is marginally degraded by imperfect adhesion, for example, areas in which oxide inclusion has inhibited the development of full bond strength. Evaluation of indications of degraded bond areas may vary in rigor from purely subjective to semiquantitative. Target supplier and user must agree upon the means used to display and grade partially bonded areas.

1.4 This practice is applicable to assemblies having planar bonds in which the design provides at least one flat plane parallel to the bond that may be used as the entry/exit surface for ultrasonic excitation.

1.5 Only the immersion pulse-echo method is covered.

1.6 Evaluation by this method is intended to be nondestructive. For target assemblies that would be degraded by immersion in demineralized water, for example, for porous target materials, the test should be considered a destructive one.

1.7 This practice is applicable to bonding methods that use a filler material to join the target and backing plate. These include solder, epoxy, and braze bonds.

1.8 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.9 *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]

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks

E 428 Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection

E 1001 Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves

E 1316 Terminology for Nondestructive Examinations

2.2 *American Society for Nondestructive Testing Standard:*

ASNT Recommended Practice SNT-TC-1A for Personnel Qualification and Certification in Nondestructive Testing[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice see Practice E 1001 and Terminology E 1316.

4. Summary of Practice

4.1 This practice describes a preferred means of applying Practice E 1001 to obtain a two dimensional map of the flaws in a sputtering target-backing plate bond. The target-backing plate assembly is immersed in demineralized water, used as a couplant, and the target-backing plate joint is scanned ultrasonically.

[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] Available from the American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

5. Significance and Use

5.1 This practice supplements Practice E 1001 by indicating specific equipment choices and test arrangements appropriate for evaluating sputtering target bonds.

5.2 The bond between sputtering target and its supporting backing plate is a critical reliability element in a sputter deposition system. A bond must have high thermal conductivity to provide adequate target cooling during sputtering. The target-backing plate joint must also have strength enough to withstand the shear stresses caused by differential thermal expansion between target and backing plate.

5.3 Flaws in a bond, for example, voids in the joining material, degrade bond performance. An inadequate bond may fail in service, potentially causing catastrophic separation of the target from the backing plate. Assurance of sound bonds is an important concern among users of sputtering equipment.

5.4 Ultrasonic testing is accepted as an efficient method for evaluating target bonds, but differences in technique inhibit intercomparison of results from one laboratory to another. This practice is intended to promote uniformity in use so that specifications for bond integrity may be universally applied.

5.5 The C-span display of ultrasonic test data is a direct method for visually demonstrating bond character. Practice E 1001 upon which this practice is modeled, however, does not address C-scan display. Instructions specific to the C-scan display mode are indicated in this practice. In other respects this practice is a section by section commentary on Practice E 1001.

6. Apparatus

6.1 *Electronic Equipment*—Provide electronic equipment in general conformance with the requirements of Practice E 1001, 6.1. It is recommended that 5 or 10 Mhz frequency be used for testing sputtering target bonds. The equipment and its cathode-ray tube (CRT) display, operating in the A-scan mode, should be capable of producing echo amplitudes of at least 60 % of full scale, with the noise level no greater than 20 % of full scale, using an 0.125-in. (3-mm) diameter flat-bottom test hole in a reference block (6.7) simulating the assembly under test. Note that for C-scan mapping of target bonds the A-scan mode is used for assisting in the setup only. A-scan data are not collected or reported.

6.1.1 *C-scan Plotter/Data Acquisition System*—The C-scan presentation is a mapping of the reflected ultrasound pulse intensity (peak voltage) from the target/backing plate interface as a function of position. Modulations of the reflected intensity“ indications” are indicative of variations in the metallurgical bond between target and backing plate. The electronic system may be equipped with a plotter to make C-scan maps on-line as the search unit traces a raster pattern over the test article’s surface.

6.1.1.1 Suitable plotters may use an electric discharge pen and conductive paper; a mechanical or electrical linkage causes the pen to traverse the paper in synchronism with the search unit’s raster of the test article. The density of the pen trace is made proportional to the reflected ultrasonic pulse from the target/backing plate interface. Alternatively, a computer-based data acquisition system may be used in which the gated reflected signal is sampled at a rate sufficient to characterize the area-modulated ultrasonic reflectance of the bond interface. These data may be plotted off-line to provide an equivalent C-scan map.

6.1.1.2 It is intended that the C-scan plotter be set to make a full-sized map of the bonded area. If a scaling factor other than 1:1 is used the enlargement/reduction factor may be determined from the reference block scan (see 8.2.3.1, 8.3.3, and 9.1.1).

6.1.2 *Plotter*—The plotter system must be capable of resolving the reference block calibration indications (6.7) with contrast sufficient to permit unambiguous identification by the unaided eye under ordinary room lighting conditions.

6.1.3 *Data Acquisition System*—The data system must be capable of displaying a C-scan mode plot of the reference block calibration indications (6.7) with contrast and resolution sufficient to permit unambiguous identification by unaided eye under ordinary room lighting conditions. A sampling rate of at least 50/in. (2/ mm) of search unit travel is recommended. Display of the ultrasonic map’s features in contrasting colors may be used to enhance visibility.

6.2 *Voltage Regulator*—Provide if necessary, in accordance with Practice E 1001 (6.2).

6.3 *Search Units*—Use round, immersion type, single element, straight-beam (longitudinal), focused search units. The focal length must be sufficiently long that the beam minimum area may be focused at the target-backing plate interface. Search units 0.375 to 0.500 in. (9.5 to 12.5 mm) in diameter, tuned at 5 or 10 Mhz operating frequency, with focal length (in water) of 2 to 4 in. (50 to 100 mm) have proved satisfactory for most applications.

6.4 *Alarm*—Not applicable for this determination.

6.4.1 *Gate Synchronization*—Set the electronic gate synchronization to lock onto the top surface echo pulse from the test article (not the primary excitation pulse) as reference. Set the gate delay and width to capture the echo pulse from the target/backing plate interface.

6.5 *Manipulating Equipment*, should conform to Practice E 1001 (6.5).

6.6 *Tank*—Provide tank in accordance with Practice E 1001 (6.6).

6.7 *Reference Blocks*—Ultrasonic reference blocks, often called test blocks, are used to standardize the ultrasonic equipment and to evaluate indications received from discontinuities in the test part.

6.7.1 It is mandatory that test blocks specifically made for sputtering target testing be provided for this procedure. Blocks should be designed, manufactured, and tested in conformance with Practices E 127 and E 428.

6.7.2 Test blocks must be 1.5 in. (38 mm) square or diameter, or larger. In order to duplicate the target-backing plate assembly, test blocks must be made of the same materials, that is, having the same acoustic properties as the article under the test, of the same thicknesses, and joined in the same manner as the target assembly to be evaluated.

6.7.2.1 It is critical for test block credibility that the bonding of target and backing plate materials be sound in areas not purposefully altered to provide calibration indications (6.7.4,

6.7.5). New test blocks should be surveyed using the method of Section 8 after laminating. Imperfect bonds should be reworked or the test blocks discarded.

6.7.3 The top surface finish of the test blocks must be the same as the article under test.

6.7.4 Three precision flat bottomed holes, arranged in a pattern as illustrated in Fig. 1 must be drilled from the back side of the test block. The diameters of the holes are 0.125, 0.250 and 0.500 in. (3, 6, and 13 mm). The holes shall be deep enough to penetrate the bond interface, ±0.005 in. (±0.13 mm). After drilling, the holes must be cleaned, tested, and sealed as described in Practices E 127 and E 428.

6.7.5 Additional purposeful discontinuities may be provided to simulate areas in which the metallurgical bond is degraded by oxide inclusions or residual contamination on the bonded surfaces. Whether such artifacts will be provided, and their nature, should be agreed upon in advance by the parties to the evaluation. The validity of purposefully degraded areas in reference blocks for simulating actual bond flaws must be verified, for example, by tensile tests, metallographic examination of bond interface sections, or by other means.

7. General Examination Requirements

7.1 *Material Condition*—Perform the ultrasonic bond test on finished target-backing plate assemblies. Baking the assembly to dry it after immersion, and final cleanup and packaging, are usual steps required to prepare the test article for delivery to a user.

7.2 *Coverage*—The bonded area should be scanned.

7.3 *Ultrasonic Frequency*—Use 10 Mhz for most applications.

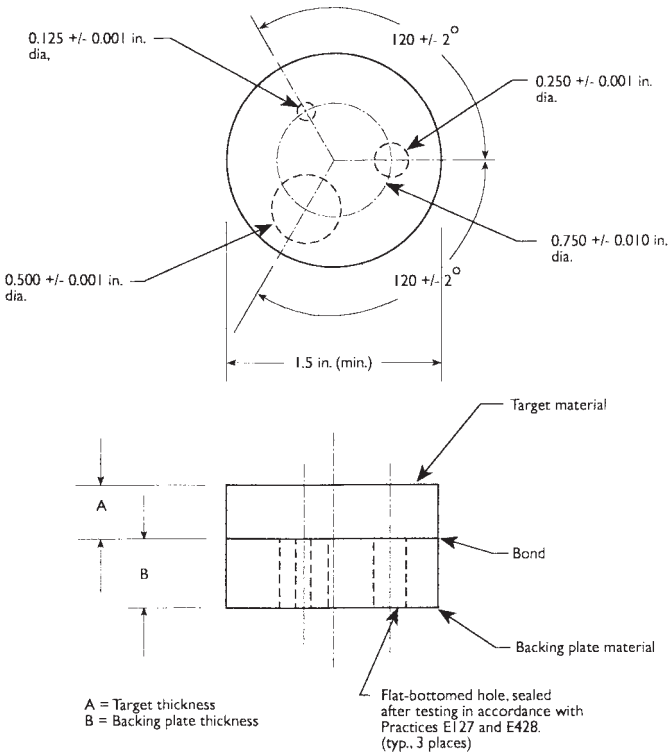

FIG. 1 Reference Block

8. Procedure

8.1 *Examination (Scanning) System Setup*:

8.1.1 *Tank*—Immerse the part to be inspected, reference blocks, and search unit in tank filled with demineralized water. Make sure that the couplant water is clean and deaerated to eliminate attenuation of the sound beam, to improve the signal to noise ratio, and to minimize contamination of the sputtering target. Do not add corrosion inhibitors or wetting agents. Remove air bubbles that collect on the test article, reference blocks, and search unit.

8.1.1.1 Generally the test article will be mounted in the tank target side up. In this orientation the target face is the entry plane for ultrasonic pulses. In special cases better results may be obtained by mounting target side down. The reference block construction must duplicate the target assembly orientation.

8.1.2 *Reference Block Selection*—Use reference blocks duplicating the target-backing plate construction. All inspections are conducted in the far field portion of the sound beam.

8.1.3 *Search Unit Adjustment*—Follow the instructions of Practice E 1001 (8.1.3) to adjust the search unit so that maximum echo amplitude is received from the sound-entry surface. Adjust the distance from the search unit to test article surface so that the target-backing plate interface is at the beam focus. This is accomplished by maximizing the pulse echo signal from the bond interface.

8.1.4 *Water Path*—Follow the instructions of Practice E 1001 (8.1.4). For most applications it is sufficient that the water path be uniform across the surface of the test article to ±0.05 in. (±1.3 mm).

8.2 *Initial Scanning Standardization*:

8.2.1 *Scan Index*—Use a scan index of 0.020 in. (0.5 mm).

8.2.2 *Distance-Amplitude Relationship*—Not applicable to this determination.

8.2.3 *Scanning Gain Determination*—Place the reference block next to the test article, and at the same height. Set the CRT display in the A-scan mode and adjust gain and gate settings to capture the echo signal from reference block's reflector holes.

8.2.3.1 *C-Scan Plotter System*—Scan the reference block, readjusting the gain settings as necessary to provide a clearly resolved image of the three reflector holes (6.7). Ideally, the holes will be saturated black against a slightly grey background. Make further refinements of the gain and gate settings as necessary to provide adequate visual contrast for additional indications, if incorporated into the reference blocks (6.7.5).

8.2.3.2 *Digital Data Acquisition System*—Activate the data acquisition system. Scan the reference block to compile a data file. Print a C-scan map. Adjust controls as necessary to provide a clearly resolved image of all reference block indications (6.7).

8.2.4 *Alarm Setting*—Not applicable for this determination.

8.3 *Initial Scanning Procedure*:

8.3.1 *Scanning Speed*—Set scan speed at the maximum value that still provides clear resolution of all reference block indications on the C-scan map. Trials at graduated speeds will generally be required to establish the suitable operating point.

8.3.2 *Coverage*—Scan the entire bond surface and the reference block.

8.3.3 *Scanning*—Position the search unit over the target assembly and reference block using the same search unit-to-part distance (water path) and angular relationship as in setup. Make sure that the system settings are the same as in 8.2.3. Mount fresh paper in the plotter and activate the pen amplifier, or activate the data acquisition system. Start search unit raster. Complete the scan of target and reference block.

8.3.4 *Indications*—Examine the C-scan map. Note that the indications from the reference block are all resolved. Note indications from the article under test.

8.3.5 *Loss of Back Reflection*—Not applicable for this determination.

9. Evaluation of Discontinuities

9.1 *Bond Voids*—Void areas in a target bond have a characteristic appearance on the C-scan map similar to the reflectors (flat bottom holes) in the reference blocks. The shade (color) is saturated and the edges are generally sharp and well defined. Various common methods may be used to quantitatively measure and total the voided area. Digital data acquisition systems may have the capability for computing and reporting the void area.

9.1.1 The apparent void area indicated on a C-scan map may be slightly larger or smaller than actual size, depending upon system parameters. Where precise measurement of voided area is required, use the indications from the known hole sizes in the reference block for correcting the apparent void areas measured on the C-scan map of the article under test.

9.1.2 The measured void areas from a C-scan map may be compared with previously agreed upon accept/reject criteria to determine the bond's suitability for use.

9.1.3 Intrusion of water into a void at the edge of a target may sufficiently couple the target and backing plates to hide any discontinuity. The bond fillet must be closely inspected visually, or the target assembly X-rayed, to detect this class of voids.

9.2 *Marginally Degraded Bonds*—Bond areas degraded by oxide inclusion, surface contamination, or similar faults are generally indicated on a C-scan map by an indistinct patchy gray-scale texture. Measuring the affected area may be imprecise because the indications are dependent upon system sensitivity. In some cases it is possible to compare the indications from the test piece with indications from a well characterized reference block (6.7.5) to achieve semiquantitative evaluation. Establishing accept/reject criteria for marginal discontinuities requires consultation and agreement among the parties to the test.

10. Quality Assurance Provisions

10.1 *Personnel Qualification*—In order to meet the intent of this practice it is essential that evaluation be performed by properly trained and qualified testing personnel. The user is referred to ASNT Practice SNT-TC-1A or other equivalent programs.

10.2 *System Performance*—The C-scan plotter/data acquisition system should be subjected to the system performance verification checks indicated in Practice E 1001 (10.1).

10.3 *Corrosion Inhibitor and Wetting Agent Control*—Use no corrosion inhibitors or wetting agents.

11. Report

11.1 Report all specific test requirements, procedural details, and results for a particular examination in written agreements, procedures, and reports.

11.2 *Contractual Agreement*—May not be applicable for this practice. Target bond testing is usually an implied requirement of the user's purchase order.

11.3 *Written Procedure and Report*—Ultrasonic inspections performed in accordance with Practice E 1001 should be detailed in a written procedure or report, or both, sufficient in detail that another qualified operator could duplicate the test and obtain equivalent information. As a minimum, the following items should be documented in the written procedure or report (see 11.3 of Practice E 1001):

11.3.1 Specific part number and configuration tested,

11.3.2 Manufacturer, model number, and serial numbers of all instrumentation used in the test. This includes all recording equipment or digital data acquisition system components, or both,

11.3.3 Type, serial number, and size of search unit. Include frequency, model number, and focal length,

11.3.4 Description of manipulating and scanning equipment, and special fixtures,

11.3.5 Couplant, clean demineralized water,

11.3.6 Scanning plan. Describe the surface from which the tests were performed and the ultrasonic beam paths used,

11.3.7 (Not applicable to this determination.),

11.3.8 Description and identification of reference blocks, and

11.3.9 Evaluation procedure.

12. Keywords

12.1 backing plates; bonding; nondestructive testing; sputtering; targets; thin films; ultrasonic testing