Designation: B490 – 09 (Reapproved 2014)

Standard Practice for Micrometer Bend Test for Ductility of Electrodeposits[1]

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1. Scope

1.1 This practice describes a procedure for measuring the ductility of electrodeposited foils.[2]

1.2 This practice is suitable only for the evaluation of electrodeposits having low ductility.

1.3 The obtained ductility values must only be considered semi-quantitative because this test has a significant operator dependence.

1.4 This practice is best used for in-house process control where measurements are always made by the same operator. A change in ductility value can be used as an indication of possible changes in the electroplating solution.

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

1.6 *This standard does not purport to address the safety problems, 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:*[3]

B456 Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium

3. Summary of Practice

3.1 This practice consists of measuring the bend of a foil held between the jaws of a micrometer; these are closed until fracture or cracks appear.

4. Significance and Use

4.1 This practice is useful as one method of controlling some electroplating solutions. It serves to indicate the presence of contamination or some other adverse condition.

4.2 Ductility measurements are of particular value when electroplated parts are to be subjected to moderate stress such as that involved in bolting an electroplated bumper to an automobile or when exposed to a wide range of fluctuating temperatures (thermal shock).

5. Apparatus

5.1 *Micrometer,* 25-mm with flat jaws to measure the thickness and to compress the foil.

5.2 Tools such as a hand or power shear, grinding wheel, file or hack saw, to initiate separation of the foil from the basis metal.

5.3 *Pair of Sharp Scissors* to cut the test specimens.

6. Test Specimens

6.1 An electrodeposit shall be prepared using a basis metal with a smooth surface from which the electrodeposit can be readily separated. Proper preparation of the surface from which the foil must be separated undamaged is critical. The deposit shall be electroplated at an average current density and under conditions (agitation, temperature, etc.) approximating those used on parts electroplated in the solution being tested. The deposit thickness shall be 25-30 µm. The panels are prepared as in 6.2.

6.2 The test panel must be properly passivated before plating to allow for separation of the subsequent deposit. Stainless steel, brass or nickel dipped in a chromic acid solution (see Note 1) for approximately 1 minute can be used as the basis metal. The panel should be properly rinsed before plating. Entering the solution with current on is recommended to prevent activation of the basis metal. When testing nickel deposits, other than rinsing, no post treatments shall be used. An alternative method is described in Note 2.

NOTE 1—For convenience, an ordinary hexavalent chromium electroplating solution can be used for preparing the basis metal.

NOTE 2—As an alternative basis metal, a piece of cold-rolled steel of any convenient size, such as 100 by 150 mm, shall be properly cleaned, rinsed, acid dipped, rinsed and electroplated with approximately 7.5 µm of nickel. After rinsing, the specimen shall be cleaned anodically for

[1] This practice is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.10 on Test Methods.

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[2] For a discussion of this test see Mohrnheim, A. F., "The Bend Test for Measuring the Strain Limit of Surfaces," *Plating*, Vol 50, 1963, pp. 1094–1099.

[3] 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.

approximately 15 seconds in a hot alkaline cleaner, rinsed, acid dipped in approximately 1 *N* sulfuric acid (approximately 27 mL of concentrated sulfuric acid added to approximately 900 mL of cold water, mixed, and diluted with cold water to 1 L), rinsed, and immediately placed in the electroplating solution of the metal to be tested.

6.3 The panel size should be selected based upon the solution volume to be used in order to maintain the additives within 85% of their original concentrations. Additions to the test solution shall not be made since they can alter the original composition.

6.4 Cut off the edges of the panel with a power or hand shear, or by any convenient method that permits ready separation of the foil from the basis metal.

6.5 Using a pair of sharp scissors, cut three or more test specimens from the center of the foil, at least 6 mm wide (but not to exceed the width of the micrometer jaws) by at least 50 mm in length.

7. Procedure

7.1 Measure the thickness of the test foil with the micrometer at the point of bending. Bend the test foil in the shape of a "U" with the side of the foil that was against the basis metal facing inward in the "U." Place the bent foil between the jaws of the micrometer so that as the jaws are closed, the bend remains between the jaws and is in complete contact with them throughout the procedure (See Note 3). Close the micrometer jaws slowly until the foil cracks (See Note 4). Use an average of three or more foil tests. Record the micrometer reading as $2R$ and the thickness of the foil as determined by the micrometer as T.

NOTE 3—If any of the bent part of the foil is outside of the micrometer jaws the force may not be uniformly distributed, which could lead to misleading results.

NOTE 4—With foils of a ductility of 70 % or greater it is helpful to examine the foil at low magnification (10×) while it is still in the micrometer.

7.2 At times, no single crack may develop over the convex surface. If jagged cracks or a series of shorter cracks develop (excluding edges), they signify failure. If no cracks develop, the maximum ductility values are obtained.

8. Calculation

8.1 Two standard formulas are used to compute ductility:

$$\text{Ductility, percent} = 100T/(2R - T) \quad (1)$$

$$\text{Maximum value is } 100\,\%. \quad (2)$$

$$\text{Ductility, ratio} = T/2R \quad (3)$$

$$\text{Maximum value is } 0.5. \quad (4)$$

8.1.1 Either formula can be used but they give different values for the same ductility. It is important that the formula be consistently used for purpose of comparison. When reporting ductility values, the formula must be indicated.

8.2 It should be understood that this value bears no simple relation to the percentage elongation obtained through tension or other tests. The ductility of this type of low-ductility electrodeposit varies with the thickness. Usually the greater the thickness, the lower is the percentage ductility for these foils. (Note 5).

NOTE 5—The foils used in this practice are 25 to 30 µm thick. Foils in this thickness range do not have the same properties as bulk metal. For example, a nickel electrodeposit 0.5 mm thick, prepared in purified bright nickel electroplating solutions for which this test is being used, had less than 3 % elongation in a tension test, and could not be bent to a 90° angle without complete fracture. However, foils 25 to 30 µm thick, electroplated at the same time, had micrometer ductility values of at least 10% when measured using this method. In order to compare results, foil thickness 25-30 m should be used. See Specification B456 for minimum ductility values for nickel electrodeposits.