This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3192 – 16

Standard Specification for High-Purity Copper Sputtering Target Used for Through-Silicon Vias (TSV) Metallization[1]

This standard is issued under the fixed designation F3192; 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 specification details the generic criteria requirements of high pure copper sputtering targets used as thin film material for through-silicon vias (TSV) metallization in advanced packaging.

1.2 Sputtering target purity, grain size, inner quality, bonding, dimension, and appearance specifications are included in this specification along with references for qualification test methods. Reliability, certification, traceability, and packaging requirements are also included.

1.2.1 *Purity Requirements:*

1.2.1.1 Metallic element impurities, and

1.2.1.2 Non-metallic element impurities.

1.2.2 *Grain **S**ize **R**equirements*—Grain size.

1.2.3 *Inner **Q**uality **R**equirements*—Internal defect.

1.2.4 *Bonding **R**equirements:*

1.2.4.1 Backing plate, and

1.2.4.2 Bonding ratio.

1.2.5 *Configuration Requirements:*

1.2.5.1 Dimension,

1.2.5.2 Tolerance, and

1.2.5.3 Surface roughness.

1.2.6 *Appearance Requirements*—Surface cleanness.

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

1.4 *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.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

B248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar

E112 Test Methods for Determining Average Grain Size

E1001 Practice for Detection and Evaluation of Discontinuities by the Immersed Pulse-Echo Ultrasonic Method Using Longitudinal Waves

F1512 Practice for Ultrasonic C-Scan Bond Evaluation of Sputtering Target-Backing Plate Assemblies

F2113 Guide for Analysis and Reporting the Impurity Content and Grade of High Purity Metallic Sputtering Targets for Electronic Thin Film Applications

F2405 Test Method for Trace Metallic Impurities in High Purity Copper by High-Mass-Resolution Glow Discharge Mass Spectrometer

2.2 *ASME Standard:*

Y14.5M Dimensioning and Tolerancing[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *backing plate, n*—plate used to support the sputtering material used in deposition processes.

3.1.1.1 *Discussion*—Assembling with the sputtering material by various bonding methods.

3.1.2 *sputtering target, n*—source material during sputter deposition processes; typically, a piece of material inside the vacuum chamber that is exposed to bombarding ions, knocking source atoms loose and onto samples.

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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 American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

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3.1.2.1 *Discussion*—The sputtering target product can be classified as monolithic or assembly type according to the configurations as shown in Fig. 1.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *finished product, n—for the purposes of this standard*, a manufactured sputtering target ready for use.

3.2.2 *material lot, n—for the purposes of this standard*, material melted into one ingot and processed as one continuous batch in subsequent thermal-mechanical treatments.

4. Ordering Information

4.1 Advanced packaging manufacturers may use this specification to specify required target performance to the supplier when purchasing sputtering target. Target suppliers may also use this specification to specify material requirements to raw material suppliers.

4.2 Orders for pure copper sputtering targets shall include the following:

4.2.1 Grade and special requirements concerning impurities (Section 5),

4.2.2 Grain size, if required (Section 6),

4.2.3 Inner quality, if required (Section 7),

4.2.4 Bonding ratio, if required (Section 8),

4.2.5 Dimensions, Tolerance and Surface Roughness (Section 9),

4.2.6 Certification required (Section 14), and

4.2.7 Whether or not a sample representative of the finished product is required to be provided by the supplier to the purchaser.

5. Purity Requirement

5.1 *Metallic Element Impurities:*

5.1.1 Grades of copper sputtering targets for through-silicon vias (TSV) metallization are defined in Table 1 based on typical metallic impurity content of the elements listed in the table. Impurity contents are reported in parts per million by weight (wt ppm). Additional elements may be analyzed and reported as agreed upon between the purchaser and the supplier.

5.1.2 General acceptable analysis methods and detection limits are specified in Guide F2113. Use Test Method F2405 to analyze the purity of copper by high-mass resolution glow discharge mass spectrometer (GDMS).

5.1.3 For most metallic species, the detection limit by GDMS is on the order of 0.01 wt ppm. With special precautions, detection limits to sub-ppb levels are possible. Elements not detected will be counted and reported as present at the minimum detection limit (mdl).

5.1.4 Other analytical techniques may be used provided they can be proved equivalent to the methods specified and have mdl less than or equal to the specified methods.

5.1.5 Acceptable limits and analytical techniques for particular elements in critical applications may be agreed upon between the purchaser and the supplier.

5.2 *Nonmetallic Element Impurities:*

5.2.1 Nonmetallic element impurities that shall be analyzed and reported are carbon, hydrogen, nitrogen, oxygen, and sulfur. Maximum limits for nonmetallic impurities shall be as agreed upon between the purchaser and the supplier. Typically, nonmetallic impurities should be as low as shown in Table 2.

5.2.2 General acceptable analysis methods and detection limits are specified in Guide F2113. Elements not detected will be counted and reported as present at the mdl.

5.2.3 Other analytical techniques may be used provided they can be proved equivalent to the methods specified and have mdl less than or equal to the specified methods.

6. Grain Size Requirement

6.1 The average and the maximum grain size shall be as agreed upon between the purchaser and the supplier. The average and the maximum grain size are generally controlled within 100 and 200 µm.

6.2 Average grain size shall be measured and reported in accordance with Test Methods E112 or another equivalent method.

6.3 Maximum grain size shall be established by making an optical or scanning electron micrograph of a polished and etched specimen typical of the finished product. The magnification shall be calibrated to ±10 % of nominal using an appropriate gage. At least 50 grains shall be resolved in the micrograph. The maximum grain size is the diagonal measure of the largest copper crystal visible in the field of view divided by the magnification.

6.4 Average grain size and maximum grain size can alternatively be established using computer-assisted image analysis methods. If image analysis methods are used, then the average grain size is defined as the mean value obtained from the grain diameter distribution data. The maximum grain size is defined as the largest grain diameter recorded in the grain size distribution set. At least 50 grains shall be included in the image analysis data set.

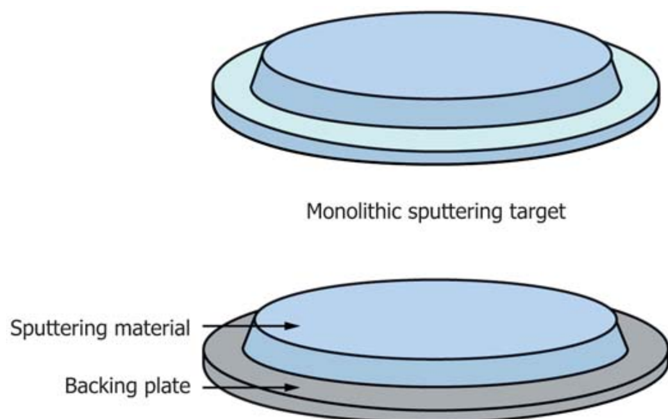

FIG. 1 Sputtering Target Configuration

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