FM Approvals®

Member of the FM Global Group

Approval Standard
for
Wafer Carriers
for Use in Cleanrooms

Class Number 4911

April 2010

Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

     a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and

     b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

This standard states Approval requirements for wafer carriers used in cleanrooms. Wafer carriers are used by the semiconductor industry to store and transport wafers. The wafer carriers not FM Approved are typically fabricated from materials that may be considered to be a fire hazard and require special protection for potential fire situations.

1.2 Scope

1.2.1 This standard sets performance requirements for wafer carriers used in cleanrooms by evaluating the ability of these products to limit fire spread and smoke damage. All requirements in this standard shall be met in order for these products to be eligible to receive Approval recognition. Wafer carriers that receive Approval recognition do not require special fixed fire protection in and of themselves.

1.2.2 This standard addresses Class 1 classification and the requirements to obtain recognition for situations when the wafer carrier is designed and FM Approved for use anywhere within a cleanroom.

1.2.3 The fire performance and smoke generation requirements contained in the standard are based on storage arrangements and fuel loadings considered to be typical of cleanrooms used in the semiconductor industry. The exposure used to qualify Class 1 wafer carriers is considered to be a fire hazard encountered by wafer carriers in a typical semiconductor fabrication facility.

1.2.4 This standard is not intended to determine the suitability for all end use conditions of a product. Conditions under which wafer carriers are used vary widely. For example, these materials may be subjected to environments, storage arrangements and fuel loadings not anticipated by this standard. In addition, this standard does not evaluate a wafer carrier's process compatibility. It is the responsibility of the manufacturer to determine the suitability of the wafer carrier's process compatibility as it relates to the effects of, but not limited to, outgassing, leaching, extraction and other related process compatibility concerns.

1.2.5 This standard does not address the issue of toxicity or outgassing of the materials when they are subjected to fire conditions nor does it address the capability of the wafer carrier to protect wafers during transport or seismic events.

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing and/or the standards of FM Approvals and other organizations. The advice of manufacturers, users, trade associations and loss control specialists was also considered.

1.3.2 Meeting the requirements of this standard qualifies a product as an FM Approved Class 1 wafer carrier. Approval recognition shall be for use anywhere in a cleanroom. Requirements prohibit component substitution without prior authorization by FM Approvals.

1.3.3 The requirements of this standard reflect tests and practices used to examine characteristics of wafer carriers for the purpose of obtaining Approval. These requirements are intended primarily as guides and strict conformity is not always mandatory. Wafer carriers having characteristics not anticipated by this standard may be FM Approved if performance equal or superior to that required by this standard is

demonstrated, or if the intent of the standard is met. Alternatively, wafer carriers that meet all the requirements identified in this standard may not be FM Approved if other conditions that adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for Approval

Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples to evaluate:

- the suitability of the product as it pertains to limited fire propagation and smoke development;
- the proper operation and performance of the product as specified by the manufacturer and required by FM Approvals.

1.4.2 An examination of the manufacturing facilities and audit of quality control procedures to evaluate the manufacturer's ability to consistently produce the product as examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of the FM Approvals' quality control follow-up program.

1.5 Basis for Continued Approval

Continued Approval is based upon:

- production, or availability, of the product as FM Approved;
- the continued use of acceptable quality control procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the -Master Agreement; and
- re-examination, if deemed necessary, of production samples for continued conformity to requirements.

1.6 Effective Date

1.6.1 The effective date of an Approval Standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or else forfeit Approval. The effective date shall apply to the entire Approval Standard, or, where so indicated, only to specific paragraphs of the standard.

1.6.2 This standard is effective immediately upon publication.

1.7 System of Units

Units of measurement are International System (SI) units. These are followed by their arithmetic equivalents in U.S. customary units enclosed in parentheses. Appendix A lists the selected units for qualities dealt with in testing these products; conversions are included. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10-97, Standard for Use of the International System of Units (SI): The Modern Metric System.

1.8 Applicable Documents

The following are standards, test methods and practices referenced in this standard:

FM Approvals Cleanroom Materials Flammability Test Protocol, Class Number 4910

FM Global Property Loss Prevention Data Sheet 7-7, *Semiconductor Fabrication Facilities*

Test Method for Fire Testing of Wafer Carriers

1.9 Definitions

Cleanroom -	A controlled environment (temperature, pressure and humidity) facility in which all air passes through a filter capable of removing 99.97% of all particles 0.2 microns and larger.
Fire Propagation - (FPI)	A ratio of the heat flux from the flame of the burning material to the *Index* material's response to this heat flux
Fire Propagation -	An index representing the propensity of the material to support fire propagation.
FOUP —	Front Opening -Unified Pod. Standardized by the semiconductor industry, it is the term used for the carrier of 300 mm (nominal 12 in.) diameter wafers.
Flame Height -	Height of flame tip visually averaged over 30 seconds (which is considerably longer than a single fluctuation [a few seconds]).
Smoke Damage — (SDI)	The smoke yield multiplied by the FPI. It is an indicator of the extent of *Index* smoke contamination of the environment during fire propagation.
Smoke Yield —	The ratio of the total mass of smoke released to the total mass of the material vaporized.
Stocker —	An automated storage and retrieval system wherein wafer carriers or FOUPs are placed on open metal frames, one deep, on both sides of the enclosure. The enclosure is typically a metal panel on four vertical sides. The bottom is typically the cleanroom floor. The top is normally open to the HEPA/ULPA filter ceiling. The wafer carriers are transported by a picker robot that traverses the stocker along its length and in the vertical direction.
Wafer Carrier —	A container, fabricated using various types of plastic, used to store, protect and transport wafers that have been fabricated in a cleanroom environment. The wafer handling tray, gaskets, hinges, handles, knobs and fittings shall be considered to be part of the wafer carrier.

2 GENERAL INFORMATION

2.1 General Background

2.1.1 Due to the sensitivity of cleanroom environments, the high cost of construction and the high value of the equipment and products produced and stored in them, extensive damage can be caused by the presence of propagating flames and relatively small amounts of smoke. In an attempt to eliminate or reduce the effect of this sensitive environment to fire situations, FM Approvals developed its Cleanroom Materials Flammability Test Protocol, Class Number 4910. Materials that meet the requirements of this test protocol exhibit fire propagation behavior and smoke contamination potential such that when used in accordance with FM Global Property Loss Prevention Data Sheets, they do not require fixed fire protection in and of themselves.

2.1.2 Since the introduction and widespread use of 4910 compliant materials, the potential fire loading contained in cleanrooms has been significantly reduced. One area of the cleanroom where 4910 compliant materials have not been widely utilized is in wafer carriers. As a result, one of the greatest remaining fire challenges in a cleanroom is associated with wafer carriers.

2.1.3 The *Test Method for Fire Testing of Wafer Carriers* utilized in this standard uses a fire loading that has been determined to be representative of the environment encountered by wafer carriers within a semiconductor fabrication facility.

2.2 Approval Application Requirements

To apply for an Approval examination the manufacturer, or its authorized representative, should submit a request to:

Materials Director
FM Approvals
1151 Boston-Providence Turnpike PO Box 9102
Norwood, MA 02062
U.S.A.

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- a complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration;
- general assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking format, piping and electrical schematics, nameplate format, brochures, sales literature, spec. sheets, installation, operation and maintenance procedures;
- the number and location of manufacturing facilities.
- all documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Approval Category

2.3.1 Class 1 wafer carriers, when used in accordance with FM Global Property Loss Prevention Data Sheets, do not require fixed fire protection in and of themselves.

2.3.2 Class 1 shall be used to indicate that the wafer carrier shall be permitted to be used in all areas of a cleanroom. In order to be eligible for this rating, the wafer carrier must meet the requirements as specified in Section 4.

3 GENERAL REQUIREMENTS

3.1 Markings

3.1.1 Each individual wafer carrier shall bear a permanent label or marking showing the manufacturer's name, model number or trade name, the Approval Mark (see Appendix B) and the classification rating. As an alternative to showing the manufacturer's name, model number or trade name, a coded symbol may be used.

3.1.2 Labels or markings denoting Approval shall be applied by the manufacturer only within and on the premises of manufacturing locations that are under the FM Approvals' product follow-up program.

3.2 Use Limitations

3.2.1 The manufacturer shall supply written information to the end user indicating the limitations under which the wafer carrier is permitted to be used.

3.2.2 All wafer carriers FM Approved under this standard, when used in accordance with FM Global Property Loss Prevention Data Sheets, do not require fixed fire protection in and of themselves. The wafer carriers shall be permitted to be used in all areas of a cleanroom as designated in FM Global Property Loss Prevention Data Sheets.

3.3 Manufacturing Locations

All wafer carriers FM Approved under this standard shall be manufactured within authorized manufacturing facilities. Facilities that produce the raw materials, flat stock or other shapes deemed to be critical by FM Approvals shall be produced within authorized manufacturing facilities that are under the FM Approvals product follow-up program.

3.4 Test Samples

3.4.1 For each wafer carrier design submitted for examination, the following product information -shall be provided:

- product trade name or designation;
- general description;
- intended usage and Approval category;
- complete list of all detail drawings, components, raw material suppliers, additives, formulations (if applicable), manufacturing procedures, equipment and production requirements; and
- Material Safety Data Sheets, if applicable.

3.4.2 Production of all samples and, at the sole discretion of FM Approvals, the raw materials used to produce the samples, submitted for testing shall be witnessed by a representative of FM Approvals.

4 PERFORMANCE REQUIREMENTS

4.1   General

4.1.1 In order to qualify as an FM Approved Class 1 wafer carrier, the product shall exhibit the ability to limit fire propagation and smoke contribution when subjected to an exposure that simulates a fire hazard typical to the environment encountered by wafer carriers within a semiconductor fabrication facility.

4.1.2 Utilize the table below to determine which test method is required.

PRODUCT	REFER TO SECTION
300 mm (12 in.) Wafer Carriers (FOUPs) which are fabricated from 99% (by weight), or greater, materials which are FM 4910 compliant	4.2
300 mm (12 in.) Wafer Carriers (FOUPs) which are fabricated from less than 99% (by weight) materials which are FM 4910 compliant	4.3
200 mm (8 in.) Wafer Carriers (Wafer Boxes with Removable Wafer Cassettes)	4.4

4.2   300 mm (12 in.) Wafer Carriers (FOUPs) – Test Method #1

There are two requirements in this section: one is a material requirement (see Section 4.2.1) and one is for fire testing the FOUP (see Section 4.2.3).

4.2.1   Requirement for the FOUP Component Materials

4.2.1.1   The individual components of the FOUP shall be tested in accordance, and comply, with the FM Approvals Cleanroom Materials Flammability Test Protocol, Class Number 4910.

4.2.2   Test / Verification

4.2.2.1 Performance shall be considered satisfactory if all samples meet the following conditions:

- ▪   99% (by weight) of all materials used in the fabrication of the FOUP shall meet the requirements of FM Approvals Cleanroom Materials Flammability Test Protocol, Class Number 4910.

4.2.3   Requirement for the FOUP Fire Test

4.2.3.1   Complete assembled units shall be tested in accordance, and comply, with the FM Approvals Test Procedure "Test Method for Fire Testing of Wafer Carriers".

4.2.4 Test/Verification

4.2.4.1   Performance shall be considered satisfactory if all samples meet the following conditions:

- the flame height shall not propagate to above the top of the FOUP array (i.e. FOUPs at the top shelf);

- fire shall not propagate to the back of the array;

- the smoke yield is less than, or equal to, 0.02 g/g of fuel (after 8 minutes of sand burner operation);

- the total smoke generated after 8 minutes of sand burner operation is less than, or equal to, 10 g (0.35 oz).

4.3   300 mm (12 in.) Wafer Carriers (FOUPs) - Test Method # 2

4.3.1   Requirement for the FOUP Fire Test

4.3.1.1   Completed assembled units shall be tested in accordance, and comply, with the FM Approvals Test Procedure "Test Method for Fire Testing of Wafer Carriers".

4.3.2   Test/Verification

4.3.2.1   Performance shall be considered satisfactory if all samples meet the following conditions:

- the flame height shall not propagate to above the top of the FOUP array (i.e. FOUPs on the top shelf);

- the chemical heat release rate shall be less than, or equal to, 300 kW (1,024,554 Btu/hr) when measured in the Fire Products Collector;

- at the end of the 5 minute period after the burner has been turned off, the heat release rate shall be less than, or equal to, 15 kW (51,228 Btu/hr) when measured in the Fire Products Collector;

- the total smoke generated after 10 minutes of sand burner operation shall be less than, or equal to, 300 g (10.6 oz).

4.4   200 mm (8 in.) Wafer Carriers (Wafer Boxes with Removable Wafer Cassettes)

4.4.1   Requirement for the 200 mm (8 in.) Wafer Carrier Fire Test

4.4.1.1   The test shall be conducted in accordance, and comply, with the FM Approvals Test Procedure "Test Method for Fire Testing of Wafer Carriers".

4.4.2   Test/Verification

4.4.2.1   Performance shall be considered satisfactory if all samples meet the following conditions:

- the flame height shall not propagate to above the top of the wafer carrier array (i.e. 200 mm [8 in.] wafer carriers on the top shelf);

- the chemical heat release rate shall be less than, or equal to, 200 kW (683,035 Btu/hr) when measured in the Fire Products Collector;

- at the end of the 5 minute period after the burner has been turned off, the heat release rate shall be less than, or equal to, 15 kW (51,228 Btu/hr) when measured in the Fire Products Collector;

- the total smoke generated after 10 minutes of sand burner operation shall be less than, or equal to, 200 g (7.1 oz).

5 OPERATIONS REQUIREMENTS

A quality assurance program is required to assure that subsequent wafer carriers produced by the manufacturer shall present the same quality and reliability as the specific sample(s) examined. Design quality, conformance to design and performance are the areas of primary concern.

- Design quality is determined during the examination and tests, and is documented in the Approval Report.
- Continued conformance to this Standard is verified by the Facilities and Procedures Audit F&PA).
- Quality of performance is determined by field performance and by periodic re examination and testing.

5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and
- handling and disposition of non-conforming materials.
- on-site handling and installation procedures
- density of installed material
- compressive strength of installed material

5.1.2 Documentation/Manual

There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture/installation

5.1.4   Drawing and Change Control

•   The manufacturer shall establish a system of product configuration control that shall allow no
          unauthorized changes to the product. Changes to critical documents, identified in the Approval
          Report, must be reported to, and authorized by, FM Approvals prior to implementation for
          production.

•   The manufacturer shall assign an appropriate person or group to be responsible for, and require
          that, proposed changes to FM Approved or Listed products be reported to FM Approvals before
          implementation. The manufacturer shall notify FM Approvals of changes in the product or of
          persons responsible for keeping FM Approvals advised by means of FM Approvals' Form 797,
          FM Approved Product/Specification-Tested Revision Report or Address/Main Contact Change
          Report.
•   Records of all revisions to all FM Approved products shall be maintained.

5.2   Facilities and Procedures Audit (F&PA)

5.2.1   An audit of the manufacturing facility is part of the Approval investigation to verify
         implementation of the quality assurance program. Its purpose is to determine that the
         manufacturer's equipment, procedures, and quality program are maintained to insure a uniform
         product consistent with that which was tested and FM Approved.

5.2.2   These audits shall be conducted periodically but at least annually by FM Approvals or its
         representatives.

5.2.3   FM Approved products or services shall be produced or provided at or from the location(s) audited
         by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the
         Approval Mark is not permitted at any other location without prior written authorization by FM
         Approvals.

5.3   Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease
of application, and conformance to written specifications. When more than one application technique is
used, one or all may be inspected at the discretion of FM Approvals.

5.4   Manufacturer's Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, components, raw
materials, physical characteristics, coatings, component formulation or quality assurance procedures prior
to implementation.

APPENDIX A: UNITS OF MEASUREMENT

Length:	in. –''inches'', ft –''feet'' (mm –''millimeters''), (m –''meters'') $mm = in. \times 25.4, m = ft \times 0.3048$
Area	in^2 –''square inches'', ft^2 –''square feet'' (mm^2 –''square millimeters'') (m^2 –''square meters'') $mm^2 = in^2 \times 6.4516 \times 10^2$ $m^2 = ft^2 \times 0.0929$
Heat:	Btu –''British thermal units'' (kW/h –''kilowatt hours'') $kW/h = Btu \times 0.000293$
Temperature:	°F –''degrees Fahrenheit'' (°C –''degrees Celsius'') $°C = (°F - 32) \times 5/9$

APPENDIX B: FM APPROVALS CERTIFICATION MARKS

FM Approvals certifications marks are to be used only in conjunction with products or services that have been Approved by FM Approvals and in adherence with usage guidelines.

FM APPROVED mark:
Authorized by FM Approvals as a certification mark for any product that has been FM Approved. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

Cast-On FM Approvals marks:
Where reproduction of the FM Approved mark described above is impossible because of production restrictions, use these modified versions of the FM Approved mark. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable.

FM Approved Mark with ''C'' only:
Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

FM Approved mark with ''C'' and ''US'':
Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with US and Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

Appendix B
FM Approvals Certification Marks
USAGE GUIDELINES

All FM Approvals certification marks are the sole property of FM Approvals LLC ("FM Approvals") and are registered or the subject of applications for registration in the United States and many other countries. They are for use only according to these guidelines.

FM Approvals certification marks may be used only on FM Approved products and related product packaging, in advertising material, catalogs and news releases. Use of FM Approvals certification marks on such material is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging.

No FM Approvals certification mark or aspect thereof may be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. This includes both design aspects (the FM Approvals "diamond," etc.) and word aspects ("FM," "Approved," etc.). The use of any FM Approvals certification mark as a trademark is strictly prohibited.

The Approval Standard number or class number may not be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. For example, a company may not say "ABC Company's 4100 Fire Door is FM Approved"; the proper terminology is, "ABC Company's Fire Door is FM Approved per Approval Standard 4100."

FM Approvals certification marks, except for the FM Approvals Quality System Registration mark, may not be used on business stationery/cards/signage because this could mischaracterize the relationship with FM Approvals. Additionally, these items should not reference any FM Approvals certification mark.

Products or services may not be marketed under any mark or name similar to "FM Global," "FM Approvals" or any of the FM Approvals certification marks. Further, products or services may not be marketed to imply a relationship beyond the scope of any Approval made by FM Approvals.

When an FM Approvals certification mark is used in advertising material or on product packaging, all material must reflect the specific circumstances under which the product was FM Approved. The material must clearly differentiate between products that are FM Approved and those that are not, and may not, in any way, imply a more substantial relationship with FM Approvals.

A company may not reference the intent to submit a product for Approval or the expectation that a company will have a certain product FM Approved in the future. For example, a company may not state, "Approval by FM Approvals pending" or "Approval by FM Approvals applied for."

FM Approvals certification marks should not be preceded or followed by a qualifier that indicates a degree of certification or acceptability. For example, "exceeds," "first" or "only" may not be used to qualify any FM Approvals certification mark.

Only original artwork issued by FM Approvals should be used. The FM Approvals certification marks should not be altered in any way other than to resize the artwork proportionately. Unacceptable uses of the marks include, but are not limited to, adding/deleting wording or artwork, reducing the artwork to an illegible size, animation or distortion.

The text of the FM Approvals certification marks may not be translated into any language other than English.

FM Approvals certification marks must appear in a size and location that is readily identifiable, but less prominent than the name of the owner of the certification or the manufacturer/seller/distributor of the certified products.