ICS 77.150.99

CCS H 66

National Standard of the People's Republic of China

GB/T XXXXX—202X

Gallium-based liquid metal thermal interface materials

镓基液态金属热界面材料

(*English Translation*)

（预审稿）

Issue date: 202X-XX-XX **Implementation date**: 202X-XX-XX

Issued by State Administration for Market Regulation of China
Standardization Administration of the People's Republic of China

Foreword

SAC/TC 243 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

This document is drafted in accordance with the rules given in the GB/T 1.1—2020 *Directives for standardization—Part 1: Rules for the structure and drafting of standardizing documents*.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The issuing body of this document shall not be held responsible for identifying any or all such patent rights.

This document was proposed by China Nonferrous Metals Industry Association.

This document was prepared by SAC/TC 243 National Technical Committee on Nonferrous Metals Standardization Administration of China.

Gallium-based liquid metal thermal interface materials

1 Scope

This document specifies the classification, technical requirements, test methods, inspection rules, sign, packaging, transportation, storage, accompanying documents, and the content of purchase order for gallium-based liquid metal thermal interface materials.

This document is applicable to liquid or paste thermal interface materials with gallium or gallium based liquid metal as the main effective thermal conductive component.

2 Normative references

The content in the following documents constitutes indispensable provisions/requirements in this document through normative references. (GB/T 1.1—2020)

The following referred documents are indispensable for the application of this document. (GB/T 1.1—2009, GB/T 20000.10—2016)

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 8170, *Rules of rounding off for numerical values & expression and judgment of limiting values*

GB/T 8928, *Standard test method for density of semi-solid and solid asphalt*

GB/T 22588—2008, *Determination of thermal diffusivity or thermal conductivity by the flash method*

GB/T 31229—2014, *Test method for volatility rate by thermogravimetry*

GB/T 39859—2021, *Gallium-based liquid metal*

GB/T 41079.1, *Test methods for physical properties of liquid metals—Part 1: Determination of density*

GB/T 4XXXX.1, *Methods for chemical analysis of gallium-based liquid metal — Part 1: Determination of lead, cadmium, mercury and arsenic contents—Inductively coupled plasma mass spectrometry*

YS/T 1258, *Nonferrous metal materials—Melting and crystallization temperatures—Thermal analysis*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in GB/T 39859-2021, GB/T 22588-2008 and the following apply.

3.1

gallium-based liquid metal

alloy with gallium as matrix metal and melting temperature less than 30 ℃

[source: GB/T 39859—2021, 3.1]

3.2

thermal interface materials

material used to fill the interface gap between a heating device and a heat sink component in order to enhance the heat transfer performance of the interface

3.3

thermal conductivity

heat flux per unit area passing through the material in the direction of heat flow under a unit temperature gradient within a unit time

Note: in watt per meter Kelvin [W/(m·K)]

[source: GB/T 22588—2008, 3.1, modified]

3.4

thermal impedance

R_A

temperature difference per unit of heat flux between two surfaces per unit area

Note: in square centimeter Kelvin per watt (cm^2·K/W)

4 Classification

4.1 Classification

The products are classified into Class I and Class II according to the presence form of gallium-based liquid metals, and the forms and product characteristics are shown in Table 1.

Table 1—Product classification

Class	Form	Characteristic
I	Continuous phase	Gallium-based liquid metals, or composite thermal interface materials with fillers in gallium-based liquid metals
II	Filler phase	Composite thermal interface materials with polymers as continuous phase and gallium-based liquid metals as fillers

4.2 Grade

The products are divided into 3 quality grades according to thermal conductivity and thermal impedance, and shall comply with the provisions of Table 2.

Table 2—Product grades

Class	Grade	Thermal conductivity (λ) W/(m·K)	Thermal impedance (R_A) cm^2·K/W
I	Grade 1	$\lambda \geq 24.0$	$R_A < 0.04$
	Grade 2	$18.0 \leq \lambda < 24.0$	$0.04 \leq R_A < 0.08$
	Grade 3	$12.0 \leq \lambda < 18.0$	$0.08 \leq R_A < 0.12$
II	Grade 1	$\lambda \geq 6.0$	$R_A < 0.04$
	Grade 2	$5.0 \leq \lambda < 6.0$	$0.04 \leq R_A < 0.08$
	Grade 3	$4.0 \leq \lambda < 5.0$	$0.08 \leq R_A < 0.12$
Note: Product quality grades shall be graded according to the lowest grade achieved in terms of thermal conductivity and thermal impedance.			

5 Technical requirements

5.1 Restricted substances

The content of the hazardous substances lead (Pb), mercury (Hg), and cadmium (Cd) in the product shall not exceed 0.01% each by mass fraction.

5.2 Physical properties

5.2.1 The thermal conductivity of the product shall comply with the specifications provided in Table 2 and be reported in measured values.

5.2.2 The thermal impedance of the product shall comply with the specifications provided in Table 2 and be reported in measured values.

5.2.3 The melting temperature of the product shall not exceed 30 ℃.

5.2.4 The density and viscosity of the product shall be reported as measured values.

5.2.5 The contact angle between the product and silicon shall not exceed 115°.

5.3 **Volatile content**

The volatile content of the product shall not exceed 0.5%.

5.4 **Appearance quality**

The appearance of the product shall be in liquid or paste, no visible foreign impurities, no significant phase separation, and in consistent color within the same batch.

6 **Test methods**

6.1 **Restricted substances**

The content of restricted substances shall be determined in accordance with GB/T XXXXX.

6.2 **Physical properties**

6.2.1 The test method for thermal conductivity shall be determined through mutual agreement between the supplier and the buyer.

6.2.2 The determination of thermal impedance shall conform to the provisions in Annex A. The test pressure shall not exceed 300 kPa, and the sample temperature shall be within the range of 40 ℃ to 100 ℃.

6.2.3 The determination of melting temperature shall conform to the provisions in YS/T 1258.

6.2.4 The determination of density of Class I products shall conform to the provisions in GB/T 41079.1 or GB/T 39859—2021, with GB/T 39859—2021 being the arbitration method. The determination of density of Class II products shall conform to the provisions in GB/T 8928.

6.2.5 The test method for viscosity shall be determined through mutual agreement between the supplier and the buyer.

6.2.6 The test method for contact angle shall be determined through mutual agreement between the supplier and the buyer.

6.3 **Volatile content**

The determination of volatile content shall be carried out in the isothermal mass-change measurement method. The test procedure shall conform to the *method A* specified in GB/T 31229—2014, where the test temperature is 150 ℃, the heating duration is 2 h, and the heating rate is less than 20 ℃/min. The volatile content can be calculated by dividing the difference between the initial and final masses at a constant temperature by the initial mass.

6.4 **Appearance quality**

Appearance quality shall be inspected visually.

7 Inspection rules

7.1 Inspection and acceptance

7.1.1 The product shall be inspected by the quality department of the supplier to ensure that the product conforms to the provisions of this document and the purchase order, and the accompanying documents shall be filled out.

7.1.2 The buyer may inspect the received products according to the provisions of this document. Where the inspection results do not conform to the provisions of this document and the purchase order, the non-conforming products shall be sealed separately and reported to the supplier in writing within 30 days from the date of receipt of the product or within the time specified in the sales contract, which should be settled by the supplier and the buyer through negotiation. If arbitration is required, arbitration sampling shall be carried out jointly by both the supplier and the buyer in the products received by the buyer.

7.2 Batching

Products shall be submitted for acceptance in batches. An inspection batch may consist of one production batch or several production batches of the same class and grade.

7.3 Sampling

Randomly take 5% of the number of inner packages from each batch of products (no less than 5 packages, take all if the batch is less than 5 packages), take 10 g ~ 20 g of products

from each package, and mix them evenly. If special packaging such as syringe is used and the net weight of each packaged product is less than 10 g, the sampling amount should be increased to meet the sample inspection amount.

7.4 Inspection items

Product inspection is divided into type inspection and factory inspection, and the inspection items should comply with the provisions of Table 3. Conduct inspection by batch.

Table 3—Inspection items and test methods

No.	Item	Type inspection	Factory inspection	Requirement	Test method
1	Restricted substances	●	○	5.1	6.1
2	Thermal conductivity	●	●	5.2.1	6.2.1
3	Thermal impedance	●	●	5.2.2	6.2.2
4	Melting temperature	●	○	5.2.3	6.2.3
5	Density	●	○	5.2.4	6.2.4
6	Viscosity	●	○	5.2.4	6.2.5
7	Contact angle	●	●	5.2.5	6.2.6
8	Volatile content	●	●	5.3	6.3
9	Appearance quality	●	●	5.4	6.4
Note: ● denotes mandatory inspection items, ○ denotes optional items.					

7.5 Inspection results judgement

7.5.1 Determination of the inspection results shall conform to the *rounded value comparison method* as specified in GB/T 8170.

7.5.2 If the content of restricted substances or appearance quality is unqualified, the batch of products shall be judged as unqualified.

7.5.3 If any of thermal conductivity, thermal impedance, melting temperature, contact angle, and volatile content is unqualified, a double number of samples shall be taken from this batch of products for a repeated test. If the inspection results are still unqualified in the repeated test, the batch of products shall be judged as unqualified.

8 Sign, packaging, transport, storage, and accompanying documents

8.1 Sign

8.1.1 Inner package sign

The following signs (or labels) shall be printed on the inner package of qualified products:

a) product name;

b) product class;

c) grade;

d) supplier name;

e) net weight;

f) batch number;

g) production date;

h) reference to this document (GB/T XXXXX).

8.1.2 Outer package sign

The following signs shall be printed on the outer package of qualified products:

a) product name;

b) supplier name;

c) quantity;

d) signs such as no-pressure and no-tilt.

8.2 **Packaging**

8.2.1 **Inner package**

The product comes in a single package. The product shall be filled into clean plastic bottles filled with inert gas or vacuum sealed. If the buyer has any special requirement, it shall be indicated in the purchase order after negotiation and confirmation between the supplier and the buyer.

8.2.2 **Outer package**

The outer packaging of the product shall be firm, pressure-proof, shock-proof, and moisture-proof.

8.3 **Transportation**

During transportation of the product, the ambient temperature shall not exceed 45 ℃, and squeezing, inversion, sunlight exposure, rain, or collision shall be avoid.

8.4 **Storage**

The product shall be stored in a well-ventilated, dry storage room where the ambient temperature is 0 ℃ ~ 40 ℃ and the relative humidity is not more than 70%. There shall be no corrosive gases such as acid and alkali in the room. The packaging box shall be elevated,

at least 20 cm above the ground, and at least 50 cm away from walls, heating equipment or air conditioning equipment.

8.5 **Accompanying documents**

Each batch of product shall be attached by accompanying documents, which shall include supplier information, product information, reference to this document (GB/T XXXXX), date of manufacture or packaging date, and should also include:

a) Product quality assurance certificate:

- Main performance and technical parameters of the product;
- Product features (including the features of manufacturing process and raw materials);
- Responsibility for product quality;
- Quality certification obtained by the product and the inspection results with seal of the supplier's technical supervision department.

b) Certificate of conformity:

- Inspection items and their results, for non-factory inspection items the test results of the latest type inspection shall be indicated;
- Batch size or batch number;
- Date of inspection;
- Inspector's signature or seal.

c) Inspection reports during product quality control and inspection report of finished product;

d) Product instructions: proper handling, use, and storage methods, etc.;

e) Others.

9 **Content of purchase order**

The purchase order for the products listed in this document shall include the following content:

a) Product name;

b) Product class;

c) Grade;

d) Quantity;

e) Reference to this document (GB/T XXXXX);

f) Others.

Annex A

(**normative**)

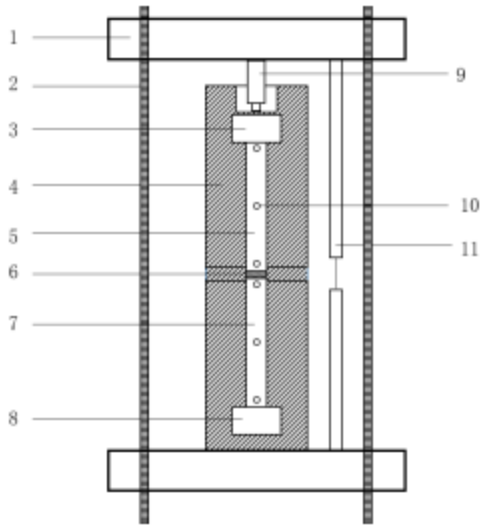
Method for determination of thermal impedance of thermal interface material

A.1 Principle

Apply thermal interface material between two solid surfaces in contact to facilitate heat flow across the interface. By measuring the temperature difference on both sides of the interface and the heat flux passing through it at a thermal equilibrium state, the thermal impedance between the surfaces can be calculated.

A.2 Apparatus

A.2.1 The thermal impedance measurement system, as shown in Figure A.1, is capable of automatically collecting data and processing it according to the specifications stated in this document. The system consists of metal rods, insulation components, lifting mechanism, measuring system, pressure control system, heating unit, and cooling system.



Key:

1——test bench;
2——lifting mechanism;
3——electrical heater;
4——thermal insulator;
5——hot end metal rod;
6——sample;
7——cold end metal rod;
8——cooling unit;
9 ——pressure sensor;
10——temperature sensors;
11——displacement sensor.

Figure A.1—Schematic diagram of the thermal impedance measurement system

A.2.2 The components and sub-units of the thermal impedance measurement system shall meet the following requirements:

a) The two sections of metal rods are made of the same metal with high thermal conductivity, usually copper rods with a diameter of 30 mm. Each rod has 2 to 5 holes with known positions and uniform distribution, in which temperature sensors can be embedded. The sample-contacting surfaces of both rods are smooth and flat, with roughness not greater than 0.1 μm and flatness not greater than 3 μm;

b) The thermal insulator can ensure a one-dimensional heat flow through the metal rods;

c) The measuring system is composed of temperature sensors and thermometer, and displacement sensor. The temperature sensor may be a thermocouple or a thermister.

The thermometer can measure the temperature in each measuring hole respectively, with an accuracy better than 0.1 ℃ and a resolution of 0.01 ℃. The displacement sensor can measure the relative displacement of the cold and hot ends with an accuracy better than 5 μm and a resolution better than 1 μm;

d) The pressure control system consists of a stepping motor, a lifting mechanism, and a pressure sensor. The stepping motor and the lifting mechanism can control the contact and separation of the two metal rods, and the pressure sensor can measure the clamping pressure along the axial direction of the metal rods;

e) The heating unit consists of an electrical heater and a temperature controller, where the maximum power of the heater exceeds 300 W;

f) The cooling system consists of a heat sink and a circulating liquid cooling device, where the temperature fluctuation of the cooling liquid is less than 0.1 ℃.

A.3 **Testing procedures**

A.3.1 Clean the contact surface of metal rods with cleaning agents such as alcohol.

A.3.2 Set the heating and cooling temperatures to the required condition. Close the test stack so that the test surfaces of the metal rods are in contact directly and apply the required clamping pressure between the rods. After the temperature distribution reaches a stable state, set the displacement sensor reading to zero.

A.3.3 Open the test stack, dispense the test sample onto the cold end test surface, and then close the test stack and apply the required clamping pressure.

A.3.4 When the temperature change of each temperature point is less than 0.1 ℃ for 30 min, it is regarded as reaching thermal stabilization. Record the temperature at each measurement point during thermal stabilization as the data for calculation and record the reading of the displacement sensor as the sample thickness.

A.4 **Test data processing**

A.4.1 The temperature gradients in the two metal rods are calculated from the temperature distribution in thermal stabilization. The temperature gradients of the two metal rods shall not differ more than 10% with each other, and their average value $(\mathrm{d}T/\mathrm{d}x)_{\mathrm{m}}$ shall be substituted in the calculation of thermal impedance.

A.4.2 The hot end surface temperature T_{H} and the cold end surface temperature T_{C} are extrapolated from the temperature distribution of the metal rods in thermal stabilization, and the difference between T_{H} and T_{C} is calculated to obtain the temperature difference ΔT_{c} at the contact interface, as shown in Figure A.2 .

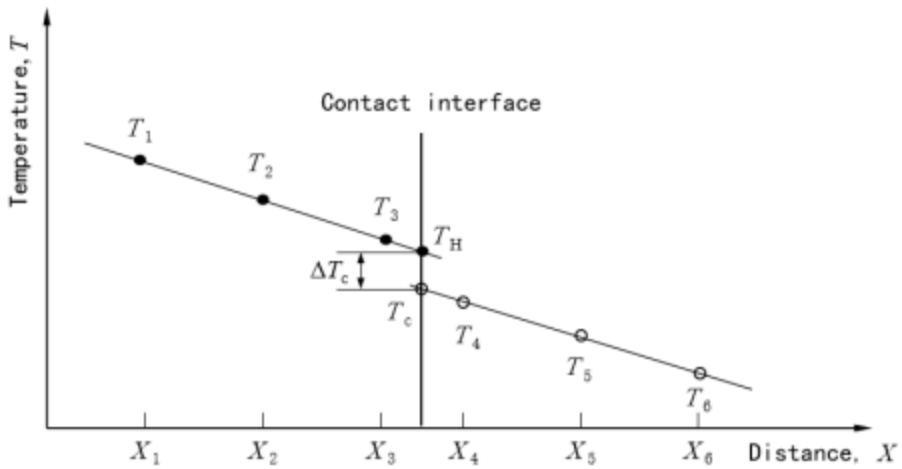


Figure A.2—Schematic diagram of calculating the temperature difference at contact interface through extrapolation

The thermal impedance is calculated from formula (A.1):

$$R_A = \frac{\Delta T_c}{\lambda_m \left(dT/dx\right)_m} \times 10000 \qquad \text{.....(A.1)}$$

where:

R_A —thermal impedance, expressed in square centimeter Kelvin per watt (cm^2·K/W);
ΔT_c—temperature difference at the contact interface, expressed in Kelvin (K);
λ_m —thermal conductivity of the metal rod material, expressed in watt per meter Kelvin [W/(m·K)];
$(dT/dx)_m$—average temperature gradient, expressed in Kelvin per meter (K/m).
The result value is reserved to 3 decimal places.

A.5 **Test report**

The test report shall include at least the following information:

——sample identification;

——clamping pressure;

——sample temperature (extrapolated hot end surface temperature T_H);

——sample thickness;

——the result and its expression;

——any occurrences noticed during the determination.

A.6 **Precision**

The absolute difference between the measured values of two independent test results obtained under repeatability conditions should not exceed 10% of the arithmetic mean of these two measured values.