EU Directive 2011/95/EC
Application for an renewal of exemption no. 7(c)-I "Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound"

1. Name and contact details

Company:	SCHOTT AG, Standort Landshut
Address:	Christoph-Dorner-Strasse 29 D – 84028 Landshut
Name:	Ms Jennifer Lüttgens
Function:	Head of Environmental protection and safety
Tel.:	+49(0)871-826-385
E-Mail:	jennifer.luettgens@schott.com

2nd Reason for application

Please indicate where relevant:

- ☐ Request for new exemption in:
- ☐ Request for amendment of existing exemption in
- ☒ **Request for extension of existing exemption in**
- ☐ Request for deletion of existing exemption in:
- ☐ Provision of information referring to an existing specific exemption in:

☒ **Annex III** ☐ Annex IV

No. of exemption in Annex III or IV where applicable: 7(c)-I

Proposed or existing wording:
Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound.

Duration where applicable: No expiry date

☐ Other: _____

3. Summary of the exemption request / revocation request

Low-melting glass solders are required to manufacture high-quality hermetic housing components for optoelectronic applications, passivation and encapsulation of semiconductor components and to hermetically connect power electronics. In the field of optoelectronic components, this property of the solder glasses is relevant because otherwise the optical windows and lenses are unusable due to the thermal load during processing. In the passivation/ encapsulation of semiconductors, excessive process temperatures also lead to the destruction of the component. The same applies to the multitude of different applications of power electronics and special applications that are manufactured using glass solder. In addition to the required low melting temperature, demands for thermodynamic stability (crystallization behavior), chemical resistance and/ or resistance to environmental influences and processability must also be met.
Among the possible glass systems, only the lead-containing solders have satisfactory properties in all points, possible alternatives fail in each case in at least one of the points mentioned

Therefore, we apply for the extension of the existing exemption in Annex III, no. 7(c)-I:

“Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound.”

4. Technical description of the exemption request / revocation request

(A) Description of the concerned application:

1. To which EEE is the exemption request/information relevant?
   Name of applications or products:

   All types of electrical and electronic equipment (EEE) (Large and small household appliances; IT and telecommunications equipment; consumer equipment; lighting equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments (including industrial monitoring and control instruments); automatic dispensers and other EEE categories not covered by any of the categories above.)

   List of relevant categories: (mark more than one where applicable)

☒ 1	☒ 7
☒ 2	☒ 8
☒ 3	☒ 9
☒ 4	☒ 10
☒ 5	☐ 11
☒ 6	

2. Please specify if application is in use in other categories to which the exemption request does not refer:

   To our knowledge this exemption is used for all categories of electrical and electronic equipment.

3. Please specify for equipment of category 8 and 9:

   The requested exemption will be applied in
   - ☒ monitoring and control instruments in industry
   - ☒ in-vitro diagnostics
   - ☒ other medical devices or other monitoring and control instruments than those in industry

4. Which of the six substances is in use in the application/product?

   (Indicate more than one where applicable)

   ☒ Pb ☐ Cd ☐ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

5. Function of the substance: As a constituent of glasses for joining and semiconductor passivation, it is essential for realisation of low working temperatures

6. Content of substance in homogeneous material (%weight): max 75%

7. Amount of substance entering the EU market annually through application for which the exemption is requested:

   Please supply information and calculations to support stated figure.

   Lead consumption in Europe in 2018 for industrial applications:
   550t ~ 750t

   [Disclaimer]
   Electrical and electronic components are used in a wide range of final products and markets, it is impossible to provide a precise figure of the amount of lead included in glass and ceramic components in the EU for Electrical and Electronic Equipment [EEE].
   The electronic equipment industry is engaged in the reduction of lead and environmental burdens within its powers, although it is impossible to completely cease the use of lead under the scope of 7(c)-I.
   We present the results of an estimate based on above survey.
   It should be noticed that there are likely to be components with lead-containing ceramic and companies which are not included.
   For this reason, although the estimates were done in good faith with the data resources available, the values shown here are provided strictly for reference purposes.

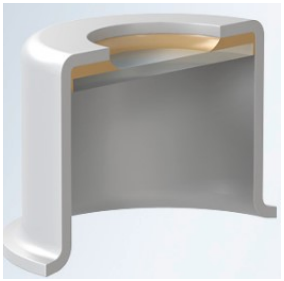
8. Name of material/component: lead-oxide based solder glasses, passivation glasses and glass frits

9. Environmental Assessment:

   LCA: ☐ Yes
   ☒ No - LCA is not applicable to this exemption renewal request

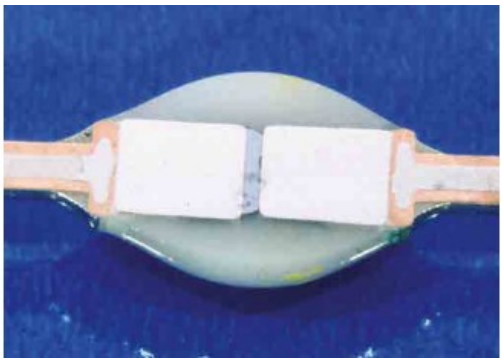
(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

Solder/ sealing glasses in the manufacture of optoelectronic components such as lens or window caps: The glass is the hermetic and electrically insulating connecting element between an optical component (e.g. window or lens) and a metallic outer conductor. The thermal expansion of the glasses must be close to the thermal expansion of the metallic and glassy components used (NiFe Alloys and the optical glasses). Due to the physical properties of the other components, processing must take place at temperatures of <500 ° C maximum temperature to avoid the destruction of the optical component. In order to protect the electronics installed inside the cap in the long term and to preserve its functionality, high demands are also placed on the chemical resistance (especially moisture at elevated temperature) of the glass. The glasses used here for joining typically have a PbO content of <75% by weight.



The yellow area shows the solder glass in the schematic drawing above

In the semiconductor industry, the glass solders fulfill important functions in the passivation of chips and diodes for special high-temperature applications. Only by optimally adapting to the thermal expansion of metallic silicon cracks and breakage in the diodes be prevented, which would otherwise lead to component failure. In addition, the glass must not negatively influence the characteristics of the pn juction and must withstand the harsh conditions of further processing and the environmental conditions of the later place of use. The glass systems generally have a PbO content of ~ 5% by weight. In special cases, this content can also be in the range of 50% by weight



Cross section of a sinter glass diode. The glass part is the off-white material around the metallic parts in the middle

(C) hat are the particular characteristics and functions of the RoHS-regulated substance that require its use in this material or component?

Due to its concentration level in the solder glass systems used the field of optoelectronic components, lead oxide acts as a low-temperature melting glass former. This is the only way to combine good chemical resistance, good wettability of the components and low melting temperature. No other metal oxide shows this extraordinary property. In addition, these glasses are thermodynamically stable across their entire processing area. This means that they show no change in properties due to applicationally unacceptable crystallization.

In the field of the glasses for semiconductor passivation, the proportion of PbO also effectively prevents the crystallization of the basic glasses and thereby avoids leaks which lead to the failure of the semiconductor. In addition, the thermal expansion can be optimally adapted to the semiconductor and the necessary chemical resistance for the downstream processes can only be achieved by adding PbO.

5. Information on Possible preparation for reuse or recycling of waste from EEE and on provisions for appropriate treatment of waste

The EU directive 2012/19/EU applies to electrical and electronic equipment (EEE). As SCHOTT AG, Site Landshut produces components for EEE and our products cannot be classified in any EEE category, the requirements of the above mentioned directive affects our customers.
We firmly assume that our customers fulfill the requirements regarding waste from EEE to the best of their ability.

6. Analysis of possible alternative substances

(A) Please provide information if possible alternative applications or alternatives for use of RoHS substances in application exist. Please elaborate analysis on a life-cycle basis, including where available information about independent research, peer-review studies development activities undertaken

(B) Please provide information and data to establish reliability of possible substitutes of application and of RoHS materials in application

Schott has been continuously developing and optimizing lead-free systems for years. There are basically two approaches to be discussed:

1) Known, application-fully functional replacement systems based on glass systems to be rejected from the EHS perspective (z.B. BeO, UO2)
2) Previously subfunctional replacement systems based on systems to be approved from the EHS perspective.

Based on the EHS guideline from SCHOTT AG Approach 1 is fundamentally out of the question.
Approach 2 can be divided into the following applications:

Application	Requirements	Weaknesses in non-lead glass solutions
Semiconductor passivation (Diode/Wafer)	• Sealing temperature <850°C • CTE <4ppm • No conductive ions • No impact on semiconductor properties • Good chemical resistance	• Chemical resistance lower • CTE of most glass systems too high • High alkaline glasses do not show sufficient electrical insulation
Low temperature sealing with NiFe Alloys	• Sealing Temperature <500°C (due to thermal damage of optical elements) • CTE >6; <8ppm • Gas tight seal (Hermeticity better than 1x10-8 mbar*l/s) • Hermeticity must maintain unchanged after 15 cycles thermal shock • No outgassing • Mechanically strong bond, Assembly has to pass stringent shock and vibration testing • Good chemical resistance • Mechanical stable up to 260°C	• All glasses show weak chemical resistance or exhibit too high melting temperature • Some glasses need excessive CTE adaption by addition of filler disabling the flow • Some glasses show early crystallisation • Some glasses lack feasibility of mass production • Overall no glass fulfilling complete requirement list
Intermediate CTE sealing	• Sealing Temperature <500°C • CTE >9; <12ppm • Chemical resistance against humidity	• For certain applications lead free solution established (i.e. joints that are protected from ambient environment) • Specifications of the majority of applications cannot be realized due to sealing glasses lacking suitable working range and acceptable chemical resistance
High CTE sealing	• CTE between 16-20ppm, sealing temperature <550°	• Lead free solution successfully established
	•	•

Success has already been achieved in some areas (intermediate soldering and high CTE sealing). On the one hand, this is due to the general nature of the glasses; those with higher melting temperatures generally exhibit a low thermal coefficient of thermal expansion (CTE), while glasses with low melting temperatures generally have a high coefficient of thermal expansion (→ silica glass with a CTE of 0.5ppm have a melting temperature >> 1600°C , for comparison a ZnO-P2O5 solder glass shows a CTE of about 13ppm a melting temperature of 500 ° C. In general it can be stated that the stronger the network character the more inflexible the glass network is).

Therefore, the existing PbO-free glasses can be used almost exclusively in specially processed components (extremely fast soldering by induction or laser) and/ or in special, encapsulated environments. Nevertheless, these systems are preferably sampled to our customers to check their suitability for the individual application. However, these glasses often - if at all - only fulfill a fraction of the required properties. In such cases, a PbO-containing solder glass must still be used to implement a technical solution

In the field of passivation, the glass systems meet a higher tolerance of process temperature. Here, glass systems can be considered which have lower CTEs at higher melting temperatures. The ZnO-B2O3 systems are promising candidates for this application. However, there is still a further need for optimization with regard to their chemical resistance.
In particular in the field of diode passivation, the current PbO-free development glasses still show undesirable interactions with the semiconductor, which reduces the electric strength to such an extent that their use is still excluded.

In the case of the Pb-free glasses for joinings with NiFe Alloys, no equivalent replacement has yet been found that meets the requirements for chemical resistance in long-term use. However, the work to eliminate the leaded glasses is continuously being advanced

However, there are fears that in special niche application with special requirement profiles the use of lead-containing glass systems cannot be avoided in the long term.
However, the development approaches listed above should lead to a massive reduction in the production tonnage of Pb-containing glass systems in this sector in future.

7. Proposed actions to develop possible substitutes

(A) Please provide information if actions have been taken to develop further possible alternatives for the application or alternatives for RoHS substances in the application.

The activities, which have been running for several development cycles, will continue. In addition to new glass compositions from the systems that are already being evaluated, new types of glass systems that may have more favorable property profiles are still being sought. All approaches are continuously promoted and tested for their applicability. In any of the application fields shown, a fully functional replacement has not been identified yet. Only when this is the case the relevant processing properties of the new material class can be determined, and thus the resulting requirements for manufacturing and post-processing be determined. This means that meaningful process development can only begin from this point in time. It is therefore absolutely necessary that the maximum exception extension is granted.

(B) Please elaborate what stages are necessary for establishment of possible substitute and respective timeframe needed for completion of such stages.

Please see 7(A). The time to find an adequate new glass system cannot be estimated for the reasons mentioned above. Due to the intensity of the unsuccessful search so far, it cannot be expected to be found quickly from today's perspective. From the time of identification, a development period of approx. 2 years can be expected, followed by a process development that typically takes 5 years in comparable cases.

8. Justification according to Article 5(1)(a)

(A) Links to REACH: (substance + substitute)

1) Do any of the following provisions apply to the application described under (A) and (C)?

- ☐ Authorisation
  - ☐ SVHC
  - ☐ Candidate list
  - ☐ Proposal inclusion Annex XIV
  - ☐ Annex XIV
- ☐ Restriction
  - ☐ Annex XVII
  - ☐ Registry of intentions
- ☐ Registration

2) Provide REACH-relevant information received through the supply chain.

Name of document: none

Based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemption would not weaken the environmental and health protection afforded by the REACH Regulation. The requested exemption is therefore justified as other criteria of Art. 5(1)(a) apply.

(B) Elimination/substitution:

1. Can the substance named under 4.(A)1 be eliminated?

☐ Yes. Consequences? _____
☒ No. Justification: see chapter 6(B)

2. Can the substance named under 4.(A)1 be substituted?

☐ Yes.
- ☐ Design changes:
- ☐ Other materials:
- ☐ Other substance:

☒ No. Justification: see chapter 6(B)

3. Give details on the reliability of substitutes (technical data + information):

Compositions (beryllium, uranium and thorium-based) are well known from the history of glassmaking and would meet the complex applicative property profile. However, due to their extremely negative EHS profile, these materials generally do not meet our requirements in terms of product safety, occupational safety and environmental protection. Therefore there are currently no adequate substitutes.

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts
   2) Health impacts
   3) Consumer safety impacts

Substance from 4.(A)1:
For the production of frit material (CAS 65997-18-4) substances might be used, which are on the candidate list and had been included in Annex XIV of the REACH regulation or could be included in future. These powdery substances are not present as such in the final frit; they are fully integrated into the glass matrix through the melting process. Thus they lose their original characteristics. With unintended use, some of these substances may be released from the matrix and become bioavailable. In this specific case the substance being relevant for hazard classification is the lead oxide. So the hazard profile of highly lead containing glasses can be described by a solution of lead oxide in non-hazardous glass matrix:

Labelling according to Regulation No. 1272/2008/EC

Hazard pictograms:

Signal word:	Danger	
Hazard statements:	H360Df	May damage the unborn child. Suspected of damaging fertility.
	H332	Harmful if inhaled.
	H302	Harmful if swallowed.
	H373	May cause damage to organs through prolonged or repeated exposure.
	H410	Very toxic to aquatic life with long lasting effects.
Precautionary Statements:		
Prevention:	P201	Obtain special instructions before use.
	P273	Avoid release to the environment.
Response:	P308+P313	If exposed or concerned: get medical advice / attention.
Additional marking:	For professional users only!	

Substitutes:
As well as for lead containing frit material the potential substitutes can be roughly classified by the EHS classification profile of those of their components available under unintended use: For exemplary comparison the GHS profiles of BeO and UO2.

Beryllium oxide:

EUROPEAN GHS CLASSIFICATION AND LABELLING

Classification:

Acute toxicity, Category 3, oral; H301
Acute toxicity, Category 2, inhalation; H330
Skin irritation, Category 2; H315
Eye irritation, Category 2; H319
Skin sensitisation, Category 1; H317
Carcinogenicity, Category 1B; H350i
Specific Target Organ Toxicity (single exposure), Category 3; H335
Specific Target Organ Toxicity (repeated exposure), Category 1; H372

Signal Word: "Danger"

Uranium dioxide

EUROPEAN GHS CLASSIFICATION ACCORDING TO REGULATION (EC) 1272/2008

Classification:

Acute toxicity, Category 2, inhalation *; H330
Acute toxicity, Category 2, oral *; H300
Specific Target Organ Toxicity (repeated exposure), Category 2; H373
Hazardous to the aquatic environment, Chronic Category 2; H411
* minimum classification

Signal Word: "Danger"

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this:

See above given examples of hazard profiles

(C) Availability of substitutes:

not applicable, there are no reasonable substitutes

a) Describe supply sources for substitutes: _____

b) Have you encountered problems with the availability? Describe:

c) Do you consider the price of the substitute to be a problem for the availability?

☐ Yes ☐ No

d) What conditions need to be fulfilled to ensure the availability?

(D) Socio-economic impact of substitution:

Since there are no technically fully applicable solutions, the only impact would be fully market loss

⇨ What kind of economic effects do you consider related to substitution?

☐ Increase in direct production costs
☐ Increase in fixed costs
☐ Increase in overhead
☐ Possible social impacts within the EU
☐ Possible social impacts external to the EU
☐ Other: _____

⇨ Provide sufficient evidence (third-party verified) to support your statement: _____

9. Other relevant information

Please provide additional relevant information to further establish the necessity of your request:

None

10. Information that should be regarded as proprietary

Please state clearly whether any of the above information should be regarded to as proprietary information. If so, please provide verifiable justification:

The information above has not to be regarded as proprietary information.