Exemption Request Form

Date of submission: 17th November 2014

1. Name and contact details

1) Name and contact details of applicant:

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2) Name and contact details of responsible person for this application (if different from above):

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Name: Torben Norlem

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Function: Chief Counsel

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2. Reason for application:

Please indicate where relevant:

X Request for new exemption in: Annex III and IV

☐ 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: _____

Proposed or existing wording: Proposed wording for new exemption in Annex III and IV: “Lead in thin film electronic sensor elements such as pyroelectric sensors or piezoelectric sensors”.

Duration where applicable: 7 years.

☐ Other: _____

3. Summary of the exemption request / revocation request

The request relate to Lead in thin film PbZrTiO3 sensors for pyroelectric or piezoelectric application. The sensors are currently used in monitoring and control instruments and the future use can possibly expand to other product groups under RoHS.

Pyreos has spent considerable resources to reduce the content of Lead in the sensors resulting in a lead reduction compared to the incumbent pyroelectric sensor technology by about a factor 1000.

As a result of the manifest reduction strategy for Lead in the sensors already implemented by Pyreos today the content is extremely low and the total yearly quantity of Lead entering the EU is **less than 1 g.**

Current alternatives are not commercially viable and substitution of Lead may potentially adversely impact the performance of monitoring and control equipment relying on the PZT thin film sensor whereby consumer and worker safety may be impaired.

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:

The request relate to thin film PbZrTiO3 sensors for pyroelectric or piezoelectric application. The sensors are currently used in monitoring and control instruments and the future use can possibly expand to other product groups under RoHS. The pyroelectric sensing element is part of a pyroelectric detector which is used for safety, security and health applications such as gesture detection, proximity detection, gas detection and infrared spectroscopy in equipment for both industrial as well as non-industrial uses.

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

X 1	X 7
X 2	X 8
X 3	X 9
X 4	X 10
X 5	X 11
X 6	

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

The sensors are currently used in Control and Monitoring equipment (category 9) for both industrial and non-industrial use. However the future use can possibly expand to other product groups under RoHS and can in time possibly include all product groups under RoHS.

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

The requested exemption will be applied in

X monitoring and control instruments in industry

X in-vitro diagnostics

X other medical devices or other monitoring and control instruments than those in industry

2. Which of the six substances is in use in the application/product?
   (Indicate more than one where applicable)
   X Pb ☐ Cd ☐ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

3. Function of the substance:
   Lead in the sensing elements of thin film PZT sensors is used for pyroelectric applications such as
   - low power Gesture / Proximity detection
   - gas detection
   - safety and security applications such as gas detection and intruder alarms
   - Infrared spectroscopy for industrial and consumer application or piezoelectric applications such as piezo actuators or transducers

   There are a total of 32 crystal configurations of which 10 are polar showing a pyroelectric effect. Ferroelectric materials form a sub-class of the polar materials and some ferroelectric materials are characterised by a very high pyroelectric effect.

   The technically most relevant material groups including some key performance parameters are shown in the table below:

Material	Example	$\varepsilon/\varepsilon_o$	tanδ	p $10^{-4}C/m^2K$	F_D $10^{-5}/\sqrt{Pa}$
Ferroelectric single crystals	$LiTaO_3$	45	0.005	2.0	4.4
Modified ferroelectric ceramics	$PbTiO_3$	250	0.007	4.2	4.3
Ferroelectric thin films on silicon	PZT	250	0.006	2.2	2.4
Ferroelectric polymers	PVDF	12	0.015	0.3	0.9

   For most application it is not only important to have a large pyroelectric effect but other factors, such as temperature dependence of pyroelectric material, its Curie temperature and the manufacturing costs are also important factors that will ultimately determine the commercial success of a sensor material.

All of the above mentioned requirements can be realised with thin-film, ferroelectric lead zircon titanate (PZT) layers (see line 3 in the table above). Compared to the most commonly used ceramic pyroelectric infrared sensors based on PZT and PT (see line 2 of the table above) the thin film PZT sensors can be viewed as nearly lead free sensors as the lead content of one thin film PZT detector is about 1/3000 of that of a ceramic PZT detector.

The lead atoms are fundamental to the unique properties of the PZT material system and it is the special electronic structure of lead together with its weight that gives the PZT material system its unique properties, cf. the detailed description below under point 4(C).

The reason for this reduction in lead lies in the significantly smaller active area of thin film PZT sensors. Improvements in the manufacturing process technology allows the thin film PZT sensor to be about a 100 times thinner and only a fraction of the area compared to ceramic PZT devices without any reduction in performance.

The key improvement in manufacturing process technology was the development of the thin film PZT sensor technology based on semiconductor / MEMs process technology. The PZT films are deposited on silicon wafers and are processed in a very similar way to standard semiconductor devices.

Being able to piggyback on the existing semiconductor/MEMs manufacturing infrastructure not only allowed a significant reduction in the lead content of the PZT based sensors but also provided a cost effective, scalable and flexible manufacturing technology to meet the performance criteria and price points of even the most demanding applications.

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4. Content of substance in homogeneous material (%weight): _____

Content of lead in the Homogenous material (the PZT thin film) is approximately 80%.

…

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

…

Based on the above calculations it can be clearly concluded that the total annual quantity of Lead entering the EU market today and for any foreseeable future through the application for which the exemption is requested is extremely low (i.e. less than 1 gram per year).

6. Name of material/component: _____

Thin-film, ferroelectric lead zircon titanate (PZT) layers in pyroelectric sensors and piezoelectric sensors.

7. Environmental Assessment: As the amount of Lead used in the sensors and thereby entering the EU market is extremely low and in effect is negligible the application for which and exemption is requested does not result in an Environmental impact which can be defined in any meaningful way. Based on the extreme low quantity of Lead introduced through the application it can however be concluded that in practical terms there will be no adverse Environmental effect from the subject application.

   LCA: ☐ Yes
   X No

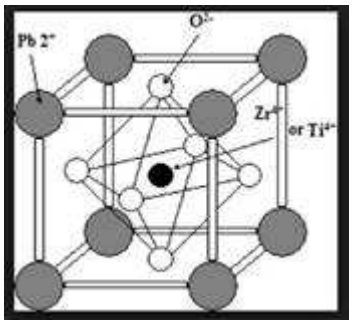
(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

The pyroelectric sensing element is part of a pyroelectric detector which is used for safety, security and health applications such as gesture detection, proximity detection, gas detection and infrared spectroscopy.

Pyroelectric detectors generate electrical charges when their temperature changes. This is very similar to piezoelectric materials which generate an electrical charge if a mechanical force is applied. Pyroelectric materials are also piezoelectric and they both belong to the family of ferroelectric materials.

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

Pyroelectric sensors as well as piezoelectric sensors require in general a polar material system with a strong permanent, switchable dipole moment i.e. a ferroelectric material system with a high spontaneous polarization. A certain crystalline structure called a Perovskite, is an especially suitable crystalline structure and most non-single crystal materials with pyro or piezoelectric properties have to be produced in such a Perovskite structure.
In the case of PZT (lead, zirconium, titanium) the actually Perovskite crystalline structure is formed by these three materials as shown in the picture below.



The lead atoms are fundamental to the unique properties of the PZT material system and it is the special electronic structure of lead together with its weight that gives the PZT material system a very strong dipole moment (spontaneous polarization) and a high Curie temperature of about 350°C (the Curie temperature is the temperature where the material system loses its spontaneous polarization). The strong spontaneous polarization of PZT is very important because it results in high pyroelectric and piezoelectric effects. As outlined above this high Curie temperature is also very important for the applications as it guarantees that the PZT sensor will operate reliably even in the most challenging environments. In addition this high Curie temperature enables PZT based sensors to be compatible with commonly used assembly processes such as surface mount technology (SMD) and reflow processes.

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

1) Please indicate if a closed loop system exist for EEE waste of application exists and provide information of its characteristics (method of collection to ensure closed loop, method of treatment, etc.)

The sensor is sold to system integrators for both industrial and non-industrial use and presumably closed loop systems will exist with system integrators for some applications of the sensor.

2) Please indicate where relevant:

X Article is collected and send without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

- ☐ The following parts are refurbished for use as spare parts: _____
- ☐ The following parts are subsequently recycled: _____

☐ Article cannot be recycled and is therefore:

- ☐ Sent for energy return
- ☐ Landfilled

3) Please provide information concerning the amount (weight) of RoHS substance present in EEE waste accumulates per annum:

☐ In articles which are refurbished _____

X In articles which are recycled …

☐ In articles which are sent for energy return _____

☐ In articles which are landfilled _____

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

Please see below answer to Question 8(B)(1) and 8(B)(2).

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

Please see below answer to Question 8(B)(4)

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.

…

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

Please refer to the answer to question 7(A) and the supporting documentation.

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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: Not relevant as none of the above requirements restrict the content of lead in the PZT thin film.

(B) Elimination/substitution:

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

☐ Yes. Consequences?

X No. Justification:

Existing lead-free pyroelectric sensors are all single crystal based, such as Lithium Tantalate (see line 1 in the table above under point 4.(A).3). These types of materials are very expensive to make as they require the growing, polishing and cutting of single crystal wafers. The costs related to this expensive crystal growing process significantly limits the commercial

application of these materials.

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

☐ Yes.

☐ Design changes:
☐ Other materials:
☐ Other substance:

X No.

Justification:

…

3. Give details on the reliability of substitutes (technical data + information):
To our knowledge and for the reasons outlined above the existing lead free alternatives do not provide the same performance characteristics as PZT

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts:
      Due to the extremely low quantities put on the EU market the environmental impact from lead in PZT thin Film is negligible.
   2) Health impacts:
      Due to the extremely low quantities put on the EU market the health impact from lead in PZT thin film is negligible
   3) Consumer safety impacts:
      Due to the extremely low quantities put on the EU market the consumer safety impact from lead in PZT thin film is negligible. However substitution may potentially adversely impact the performance of monitoring and control equipment relying on the PZT thin film detector whereby consumer and worker safety may be impaired.

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this:
As substitution currently still require substantial research and development activities that has not been completed, the impact and benefits of substitution cannot be evaluated at this point in time.

(C) Availability of substitutes:

a) Describe supply sources for substitutes: Not relevant.

b) Have you encountered problems with the availability? Describe: Not relevant.

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

X Yes ☐ No

d) What conditions need to be fulfilled to ensure the availability? Not relevant.

(D) Socio-economic impact of substitution:

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

X 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

X Other: Substitution may potentially adversely impact the performance of monitoring and control equipment relying on the PZT thin film detector whereby consumer and worker safety may be impaired.

⇨ Provide sufficient evidence (third-party verified) to support your statement: As substitution currently still require substantial research and development activities that has not been completed, the impact and benefits of substitution cannot be evaluated at this point in time.

9. Other relevant information

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

All relevant information has been provided in this application and supporting documentation. However Pyreos will cooperate proactively with the EU Commission and it's representatives and stakeholders to provide any further information required in this respect.

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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:

Applicant considers the below information as proprietary and request that this information is kept confidential as the information is commercially and technical sensitive where publication will result in loss of market share and competitive disadvantage.

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