Adaptation to scientific and technical progress under Directive 2002/95/EC

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4.38.4 Recommendation

It is recommended not to grant the requested exemption. The applicant did not answer the consultant's questions on his exemption request.

4.39 Exemption request No. 4

"Cadmium within a colour converting single crystal semiconductor film for use in solid state illumination or display systems"

4.39.1 Description of request

Based on the exemption request by 3M (Minnesota Mining Manufacturing) submitted in April 2008 [1], II-VI colour-converted semiconductor light emitting diodes (II-VI LEDs) represent a revolutionary technology. This technology is currently not purchasable – even on the US market – but is planned to be put onto the European market by 3M in 2009.

As one specialty, the emission wavelength from the II-VI film can be tuned anywhere within the visible spectrum leading to an extremely good colour rendering. This is particularly important for the application in mobile projectors as the colour rendering is one of the main quality factors. At the present level of knowledge the II-VI material is therefore the only material system capable of light emission across the entire visible spectrum currently available.

3M submitted a request to the RoHS Directive because the II-VI-LEDs are intended to be used as replacements for Hg-containing lamps and conventional LEDs – especially in the mobile projector sector – and therefore fall under the scope of RoHS when used in lamps. The applicant also intends to increase the transition from gas discharge lighting to solid state lighting via this new LED technology. The main advantages of this technology compared to other light emitting sources are increased energy efficiency due to low power consumption [2] and increased lifetime (compared to all other conventional light sources apart LEDs).

3M expects the II-VI LEDs lifetime to be similar to those of conventional LEDs (35 000-50 000h). For mobile projector application the device lifetime is expected to be 20 000h. In comparison Hg-containing lamps for mobile projectors have an averaged lifetime expectancy of 8.620 h [3] [4].

Additionally II-VI LEDs provide sufficient colour saturation, instant-on, a small size as well as a high luminous efficacy (80 lm/W compared to 50 lm/W for commercial LEDs and fluorescent lamps) [3].

Concerning the amount of cadmium (Cd) used in these LEDs, the 0.3-9 µg Cd per II-VI LED (depending on the size of the LED) is a fairly small amount. In general, estimations of 3M predict less than 10 kg per year for all II-VI colour-converted LEDs distributed within the EU [1]. As the Cd is also tightly bound within this material, it represents no risk to human health

and the environment initially. Furthermore, 3M points out that recycling is possible and that the company would work with the OEM who integrates the II-IV colour-converted LED-device into the final product in order to create a recycling program [3].

The applicant has requested an exemption with the following wording:

Cadmium within a colour converting single crystal semiconductor film for use in solid state illumination or display systems.

4.39.2 Justification by stakeholder

3M being the original applicant forwarded the only contributions within this review / stakeholder consultation process ([1],[2],[3] and [4]). Because of advantages regarding unique optical properties, energy efficiency, waste reduction and even the reduction of the use and the release of heavy metals to the environment in general (as will be explained below) 3M requests the grant of request 4.

The three main advantages of this special LED technology have been brought forward by 3M as summarised in the following:

Reduce the quantity of heavy metals released into the environment

According to 3M the new II-VI LEDs are foreseen to replace compact fluorescent lamps (CFLs). As CFLs contain mercury and additionally some other heavy metals in their lamp sockets, 3M points out that there is a higher necessity for heavy metals for CFLs than for II-VI LEDs. Nevertheless, the amount of Cd in the packaged II-VI LED will be very small (3M estimates a concentration of 8ppm). Because recycling for II-VI materials is possible the amount of Cd for the production of these devices can probably be even more reduced [3].

No other heavy metal than Cd is used to produce these II-VI LEDs, therefore the total impact of hazardous substances under the RoHS Directive appears to be relatively small.

Reduce the amount of energy needed via an improved energy efficiency

Beginning with the production process it is already important to note that with II-VI LED technology several improvements in manufacturing have been accomplished:

- During the device fabrication very little loss of material and therefore energy has been attained.
- Additionally, the waste of “bad LEDs” as for e.g. green-emitting LEDs can be reduced.
- Finally, the improvement of wafer-technology for II-VI LEDs also induces energy savings because of simultaneous fabrication of more than 10 wafers within one run [3].

Furthermore, the II-VI LEDS itself with its low power consumption and its extended lifetime compared to fluorescent lamps reduce the amount of energy needed throughout the whole II-VI LED lifetime.

Reduce the quantity of electronic waste (reduction of volume and number of electronic components)

The above mentioned energy savings via waste reduction (from the fabrication process up to the end-life recycling option) as well as the expected longer lifetime of these LEDs also contribute to a reduction of electronic waste in general.

4.39.3 Critical review

Comparison with other lamps (Fluorescent lamps & conventional LEDs):

As argued by 3M, in contrast to fluorescent lamps II-VI colour-converted LEDs do not contain other heavy metals than Cd since they do not contain lead as it is present in other lamp sockets. Additionally the amount of Cd is negligible compared to the mercury amount used for the production of fluorescent lamps [3]. However, the consultant is not in the position to balance or measure if the amount of heavy metals needed for CFL production represents a higher risk for the environment than the amount of Cd for the production of II-VI LEDs.

Compared to conventional / typical LEDs, II-IV colour-converted LEDs overcome the following limits as pointed out by 3M:

- "Limited range of wavelength commercially available [1]"– For II-VI LEDs it is unlimited within the visible spectrum for II-IV colour-converted LEDs.
- "Large variation in colour on individual wafers so that only a small fraction of LEDs emit light within an acceptable range for demanding applications. The rest are suitable only for low quality applications or are waste [1]." Undesirable characteristics and reduced performances caused by commercial LEDs or the combination of them are overcome by this technology which simply uses one LED for rendering different colours.
- "Power efficiency for green and yellow LEDs is lower than for blue and red [1]." As II-VI colour converted LEDs possess a 50% higher efficiency than conventional LEDs they also have a reduced power consumption.

Thus, II-IV colour-converted LEDs are considered suitable to replace current LED technology with an environmental benefit due to a higher energy efficiency at certain colours.

Environmental Risks:

As the amount of Cd contained within the II-VI colour-convertor material is covalently bound within the semiconductor lattice and additionally encapsulated within a glassy protective coating, it is stably bound and the possibility of release to the environment is greatly reduced. However, this is not an argument in line with Article 5 (1) (b) since only the impracticability of substitution or its negative effects can be taken into consideration.

Research for Substitution of Cd

According to the stakeholder contributions it is currently impossible to substitute or eliminate the cadmium in II-VI colour-converted LEDs without seriously deteriorating the performance. Because of the reduced colour range of Cd-free material the visual spectrum can not be covered completely in example (see [3] 5). However, 3M points out that research for Cd-free technology is in progress although a commercially available Cd-free technology will not be available within at least the next 4 to 5 years [2].

Since no sound data based LCA is currently available for this new technology a full assessment of the validity of the argumentation by 3M is not possible. Especially evaluation on whether a gain in efficiency compared to conventional LEDs and Hg-containing lamps outweighs the negative effects of heavy metal use can not be carried out. More scientific research is needed.

4.39.4 Recommendation

Against the background that solid-state lighting is intended to replace applications of fluorescent lamps, the described II-VI-colour-converted LEDs with their improved performances than typical LEDs (explained above) represent an exemption request which is justified according to Article 5 (1) (b). It is thus recommended to be granted temporarily until the next revision of the Annex of the RoHS Directive (expiry date 31 July 2014).

However, in order to avoid misuse based on a too general wording we recommend changing the wording of the current request into the following:

"Cadmium in colour converting II-VI LEDs (< 10 µg Cd per mm^2 of light-emitting area) for use in solid state illumination or display systems".

4.39.5 References

[1] Original Request: "Cd in Colour-Converting Illumination or Display Systems.pdf"

[2] 3M E-Mail right after Meeting:
"3M's ROHS exemption Request Action items from discussion on 9-15-2008.msg"

[3] 3M submission to RoHS request no. 4:
"3M response to stakeholder consultation_2_23.September 2008.pdf"

[4] 3M submission to request no. 4, "3M additional info Cd in II-VI SSL_22Oct2008.pdf"