OSRAM / OSRAM Opto Semiconductor

Comments to the Webinar of Öko-Institute/EU Commission on RoHS Pack 15 Exemption Evaluation Methodology with regard to the presented examples from the evaluation of

- Extension of Exemption 39(a) of Annex III (April 30, 2018)
- New exemption for the use of Cadmium in luminescent material for on-chip application on LED semiconductor chips (lighting) (September 29, 2017)
- Evaluation of other exemptions applied by LightingEurope in Jan 2015

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1 InP: uses and amounts

In the webinar an amount of 60 kg Indium Phosphide was mentioned for display and lighting. OSRAM would like to reiterate that we are not aware of any practical direct use of InP in lighting in Europe. The 60 kg mentioned are only used in display technologies. On-edge and on-surface applications are not suitable for lighting.

You come to the conclusion, that
"*A restriction is not expected to generate benefits for the environment and for human health*".

We fully share the opinion that a restriction is not justified due to the amounts of InP used in products.

But we are working on an on-chip technology as described in the renewal application of April 30, 2018 and in the stakeholder consultations which can realize 96-98% reduction of hazardous substances related to QD application as well as better color quality and better energy efficiency. In addition, new applications in µ-display and µ-projection technology will be made possible. These applications are requested by customers and not possible with on-edge and on-surface QD technology.

2 Exemption evaluation methodology

In the webinar Öko-Institute described the current status of exemption evaluation methodology and brought some examples coming from the exemption renewal and new exemption request for the use of Cadmium in luminescent material for LED. We would like to comment some of the presented examples and add examples from our experience with the evaluation of exemptions required for lighting.

2.1 Article 5(1)(a) criteria – "*1st and 2nd criteria*"

"their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable"

In your example you make the statement, that

- "*indium phosphide is also applied in displays (marketed) and lighting*" and
- *Other types of display and lighting are available on the market*".

This statement is wrong and/or misleading. Indium phosphide is not applied in lighting. There is no development of such products we are aware of. Only cadmium QD in on-chip configuration brings the energy efficiency increase of > 20% compared to best available lighting technology with trace amounts of Cd per LED as described in our contributions and measurements. CdQD products <u>are</u> on the market for lighting and winning awards. But as currently only an amount of <100 ppm Cd in the luminescent materials is allowed the big energy efficiency increase of 20% cannot be achieved. Such products with amounts <1000 ppm are ready for marketing and

production since more than 1 year in our company. Products of similar capabilities of a competitor were ready for the market even earlier but discontinued, among other reasons, due to the missing exemption. Such products are perfect to contribute to the goals of the EU Green Deal:

- Extraordinary increase of energy efficiency with trace amounts of the substance Cd
- Reduction of the total amount of emitted Cd from a life cycle perspective due to less emission from coal-fired power plants
- Reduction of other toxic and hazardous substances and emissions, e.g. Hg, Pb, CO_2 and ozone depleting substances. These improvements would even count more in regions outside EU where less effort is spent to change power production.
- Availability of highly efficient CRI 90 products will increase the substitution of fluorescent and high pressure general lighting technologies (e.g. lamps falling in exemption 2(b)(4)) due to the better light quality and energy efficiency. While the calculations given by LightingEurope and OSRAM are based on lower uses there are indeed usage scenarios with more than 1000 h per year.

Products using InP QD for lighting are not suitable and not available. Such products with on-surface or on-edge applications would not be competitive compared to standard LED for lighting. They would even have difficulties to reach energy efficiency of fluorescent lighting.

On-chip application of InP in QD LED failed so far. OSRAM has worked with this material in cooperation with NANOCO. It was never possible to develop stable InP based on-chip products. Therefore the exemption renewal request of OSRAM for on-chip use of CdSe for displays is not comparable with uses of on-surface and on-edge applications currently on the market in high quality TVs.

Use of on-chip Cd QD LED can have the following advantages with extremely low amounts of Cd:

- Increase of colour quality and energy efficiency compared to current QD solutions
- More than 99% reduction of hazardous substances: while about 30 mg InP (carcinogenic nanomaterial) is used for a 55” TV far less than 1 mg Cd would be required using on-chip configuration LED. While for Cd a warning is to be applied according the ErP implementing Ecodesign requirements for displays such a warning will not be found in TVs with InP QD materials.
- Only on-chip configurations can lead to the development of innovative µ-display and µ-projection applications as planned by OSRAM.
- Energy and material efficiency increase is expected in multiple areas.

In light of these advantages, we do not agree with your conclusion on slide 9 that InP technology is considered a substitute or alternative technology within the meaning of the 1st and 2nd criterion listed in the methodology, nor with the statement that other technologies are available on the market. The criterion is to identify comparable

technologies, i.e. those that deliver equal or better performance. InP technology does not deliver the same or equivalent performance as the use of on-chip QD LED. Also current conventional, phosphor based CRI90 LED only perform at 80% of the energy efficiency of the on-chip QD LED and do not achieve comparable levels of colour quality.

2.2 Article 5(1)(a) criteria – "3rd *criterion*"

LightingEurope provided LCA data as well as measurement results clearly proofing that a >20 % increase of energy efficiency in lighting LED is achieved and that this improvement leads to a total reduction of Cd emissions during the life cycle compared to best in class CRI90 Cd-free products.

We agree that a service life of 30 years for TVs is not a realistic scenario for a comparative LCA. Neither LightingEurope nor OSRAM have used such a scenario – the statement in slide 10 is therefore not correct or misleading. Nanjing has provided data compiled by ERA Technology using a 10 year scenario.

There were also arguments in the stakeholder consultation, that the Cd emissions will decrease with the use of more and more renewable energy. This statement is misleading. The LightingEurope data were based on the EU energy mix. Only reduction of energy consumption can make it possible to phase out coal-fired plants with all their environmental disadvantages as required in the EU Green Deal. CdQD LED with trace amounts of cadmium can support this as outlined above and help to avoid emissions in the coming years. Avoided energy consumption also needs no Cd in solar panels, which is so far allowed, as these products are exempted in the RoHS Directive.

For on-chip CdQD display technology we are convinced that the *"3rd criterion"* is fulfilled as well with higher efficiency but also with a >99% hazardous substance reduction in the product (see above) compared to other configurations.

All LCA on general lighting products performed by OSRAM and other LightingEurope member companies clearly show that the biggest environmental impact occurs in the use phase. Most of our products showed that less than 4% of the impact falls in the production phase, see www.osram.com/lca.

2.3 Article 5(1)(a) criteria – "4th *criterion*"

LightingEurope has provided a 3rd party Socio-Economic Impact Analysis (SEA) in Sept. 2017 providing information on the impacts of an exemption for Cd in QD LED and to demonstrate the socio-economic benefits related to the exemption outweigh the risks to human health and environment. The SEA is based on a cost and benefit analysis and all impacts associated with a policy decision were analyzed from a societal perspective and quantified in monetary terms, whenever possible. Given the favourable environmental properties of cadmium-containing QD LEDs and the associated expected benefits in the exemption scenario, the SEA demonstrated

clearly that the benefits – from social perspective – will outweigh the costs. This is today even more the case as the high need of energy efficient products is more recognized and demanded by society.

- The benefit regarding reduction of Greenhouse gas emissions was calculated
- The power savings in GWh were estimated, total savings per year as well as cumulative until 2022
- The amount of Cd required for the exemption was calculated for different scenarios and compared to other emissions and deposition on soils
- The use of CdQD LED as requested by LightingEurope leads to a net decrease of cadmium emissions to the environment
- Toxicity Characteristic Leaching Procedure test has been performed as input for the LCA on on-chip CdQD resulting in no cadmium release in the environment
- Cadmium-based QD LED packages dominate conventional phosphor LED packages in all LCA assessment categories
- Analysis of potential health effects clarified that only in the production process there are some risks. But Cadmium can be handled safely with the right measures so that no risk is posed to workers.
- The use of Cadmium in other EEE and especially lighting application was addressed
- The consultant also acknowledged the demand of certain markets and applications for high CRI (>90) lighting such as for consumers in kitchen bath- or living rooms, museums, shops, hotels, stadium lighting, hospitals
- The potential for reduction of electricity costs are highlighted. These costs are increasing in some EU member states year over year due to the switch from fossil to renewably energy.
- The huge Research and Development efforts and success is highlighted

OSRAM is relying on the Öko-Institute and its partners that these arguments are taken into account for the CdQD on-chip exemption evaluations.

2.4 Article 5(1)(a) criteria – "*5th criterion*" – Influence on innovation

The RoHS Directive advices that adverse impacts on innovation may be considered. In the example given Öko-Institute mentions that "*in the presence of InP QD technologies for displays and lighting an exemption for CdSe QD could affect the rate of innovation of further developments*".

We are of the opinion that this example is completely wrong and misleading. It is exactly the other way round – in the present case it is the non-granting of this exemption that will stifle innovation and discourage companies to invest in R&D to develop ever-better technologies, because they have no reassurance that their innovation will be allowed under RoHS and that they will get a return on their investment.

The development of efficient down-converter materials is one of the research and development (R&D) priorities in LED technology. All the LCAs with lighting products show it is the energy consumption in the use phase that has the biggest environmental impact in the total life cycle of these products, more than 96% according the LCAs done with OSRAM products (www.osram.com/lca). Not granting an exemption for trace amounts of Cd in QD LED will lead to the situation that millions of € were spent by European companies to develop highly energy efficient products that then will not be used. All the benefits of this technology cannot not be realized without exemption which would be counterproductive to the targets of the EU Green Deal.

On-chip configurations can so far not be realized with InP. OSRAM has done intensive R&D with InP partly in collaboration with NANOCO but it turned out that the material is not suitable for on-chip QD conversion either in optical performance or in stability and that this will remain the case in the foreseeable timeframe. The technical breakthrough came with cadmium quantum dot material in on-chip configurations and paves the way for developing alternative quantum dot compositions.

For sure it was not the Cd exemption that hampered the innovation of InP QD materials. On the other side the proposal and the decision not to grant an exemption for CdQD LED in 2016/17 was a significant setback in the attempts to improve energy efficiency and quality in lighting. In addition, the long duration of exemption and renewal evaluations of now again more than 2.5 years is a major threat to all R&D activities giving advantages to non-EU companies and areas.

Looking at other exemptions it also turned out that granting an exemption did not hamper the development of substitutes. The best example for this statement are the mercury exemptions. Despite the fact that the use of this substance is still allowed the development of highly efficient LED products was not affected, because the new technology had increasingly better efficiency and quality performance so that step by step the new technology entered the market and is already now nearly exclusively used in new installations while the fluorescent lamp market has developed to a market for replacement lamps in existing luminaires (spare part character).

Also, the exemption for lead in printing inks did not stop manufacturers to replace lead which is now no longer needed for lamps.

Better (quality and performance) *is always the enemy of the best* (quality and performance). Every manufacturer using an exemption is aware that the justification can stop if an alternative fulfilling the RoHS Art. 5(a)(1) requirements becomes available. Therefore, also OSRAM is already spending >R&D effort for Cd-free QD LED in on-chip configuration. This will likely increase in the case that the 1st generation of QD products are successful and be reduced in case they are not.

Regulatory uncertainty for the current generation of QD technology adds risk surrounding its uptake in the market and hampers investment in all future QD technologies. This uncertainty has already caused delays in bringing mature and

reliable QD technologies and the associated energy and environmental savings to market.

Regarding the duration of an exemption it is true, that if an application is still in development a shorter duration can give the chance to once more evaluate the justification of an exemption. On the other side a short duration discourages potential customers to develop products using new technologies due to the high risks of investments which then might not pay off. A much better alternative would be to give the development more or maximum time. If the promises given in the application turn out to be true the product will be successful and an additional renewal time and resource consuming renewal would not be necessary. If the product is not successful it will not be produced and the renewal will not be requested. If the exemption only leads to a product which is not fulfilling RoHS Art. 5(a)(1) requirements an application could be started to revoke the exemption. In the case of CdQD exemptions this could have helped a lot to already now have products on the market with higher colour quality and dramatically increased energy efficiency for certain applications.

3 Putting the use of Cadmium in CdQD in perspective

The following comparison is not directly relevant regarding RoHS Directive as there is no absolute limit for a substance but only a limit based on the “homogenous material” which has an not really clarifying definition. But the data can help to show that there are other allowed uses or limits for Cadmium which are much higher. Even food is allowed to contain more Cd as contained in an energy safing lighting product. This comparison should help to bring the negative effects of the use of some micrograms of the hazardous substance Cadmium into perspective.

Cadmium is a chemical element occurring in natural products as well as in food. The allowable amount in food is usually higher than used in a LED lamp suitable to replace a 60Watt incandescent lamp. Other applications in lighting technology show many orders of magnitudes allowable Cd amounts: NiCd accumulators can be found in emergency luminaires as they are exempted from EU Battery Directive. These products can contain packages from 200 up to nearly 1 kg, the Cd content is 10% plus 26,7% CdO and have much shorter lifetimes than the luminaire (see example sources[1] [2])

[1] https://www.tridonic.com/com/en/download/technical/Material_Safety_DS_NiCd_Tridonic_en.pdf
[2] https://www.tridonic.com/com/en/download/data_sheets/Accupack_NiCd_1.6-4.5Ah_en.pdf

Application / natural occurrence	Cd amount
1 CdQD LED for lighting (<100 ppm) RoHS conform	< 0.0000005 g
1 CdQD LED for lighting (<1000 ppm)	< 0.000003 g
1 “60W” lamp CRI90 with 6 LED (<1000)	< 0.000018 g
100 g chocolate (>50% cacao)[3]	0.000004 - 0.000023 g legal limit in EU: 0.0008 g
Pommes frites[4]	0,00004 g/kg
NiCd accumulator; exempted in emergency lighting; E.g. Tridonic packs from 200 g up to 990 g	>60 - <300 g per luminaire 10% Cd plus 26,7% CdO

[3] https://www.lgl.bayern.de/lebensmittel/warengruppen/wc_45_kakao/ue_20018_cadmium_in_kakao.htm

[4] https://verbraucherschutz.sachsen-anhalt.de/fileadmin/Bibliothek/Politik_und_Verwaltung/MS/LAV_Verbraucherschutz/lebensmittelsicherheit/schwerpunktberichte/schwerpunktberichte2015/12_2015.pdf