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Comments on ROHS Annex II Dossier for Indium phosphide

Dear Öko-Institut,

we have noticed from Fraunhofer HHI that the stakeholder consultation for InP is currently taking. Fraunhofer IAP has been working on the InP-based QD synthesis and its application in different technologies including display since 2009. The InP-based QD is only the possible alternative for red and green (R/G) color in terms of device performances, as shown in Figure 1, since InP considered as safer technology compared to Cd-based QDs[1].

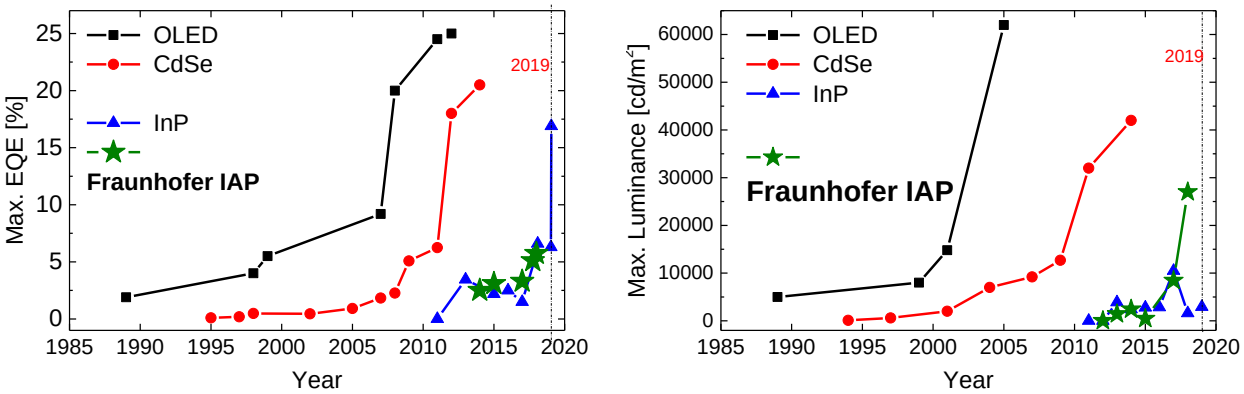

Figure 1. The development history of EL-QLEDs with InP-based QDs, compared to OLEDs and CdSe-based devices[2] (source: Fraunhofer IAP).

We have reviewed "ROHS Annex II Dossier for Indium phosphide" and our comments are as follows;
First of all, the "on-chip" configuration mentioned in "ROHS Annex II Dossier for Indium phosphide" is based on QD-MicroLED display which is similar to QD-OLED technology, where they use an only different blue light source with the

similar R/G QD color converting layers. Since Micro-LED display has other issues on the production yields[3] and the QD material stability on LED chips[4], QD-OLEDs will be firstly in the market from around 2021, based on the SDC's recent news[5], and QD-MicroLEDs can come after those.

In the Öko-Institut's assumption on InP-based QD usage in 2028 within the EU, there are some important factors are missing. First, the InP amount per square millimeters (c.a. 0.03 g/mm^2 in 2018) will keep decreasing since the technology will incorporate more efficient QDs into QLED TV, then the technology needs the less amount of QDs for the same performance.

Second, the InP usage will be also decreased when QDEL (i.e. Electroluminescent (EL)-QLEDs) is available in the display market because the QDEL technology will use much less amount of InP-based QDs in the devices. For instance, the QD layer thickness is around 10~50 nm in QDEL[6,7], but around 10 μm in QD-OLED[8]. Additionally, the blue QDEL in the display will incorporate with ZnSe[9]-based QDs but not with InP, which also reduces the actual display area where InP-based QDs are embedded.

Furthermore, the commercialization of QD-OLED/QD-MicroLED and QDEL display will strongly depend on the level of technology developments based on InP-based QDs. Since there are still several challenges remained for those technologies[10], it is somehow difficult to predict the realistic amount of InP usage, unless the actual QD industry companies provide very detailed market expectations with some practical numbers.

In conclusion, if InP becomes regulated under RoHS with similar exemptions like "Cd- based QDs", the QD display technologies based on InP-based QDs cannot be efficiently developed in both industry and research/academic area. Then the current "Cd-based QDs" technology will be asked to use again and again in the consumer electronics even though their current regulations and hazardless, because there are no other safer technologies which can replace Cd-based QDs except InP-based QDs.

If there is any further information that you require please do not hesitate to contact us.

Yours sincerely,

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1 https://doi.org/10.1039/c2nr33024e
2 https://doi.org/10.1038/nphoton.2012.328
3 https://doi.org/10.3390/app9061206
4 https://doi.org/10.1039/C8RA00119G
5 https://www.zdnet.com/article/samsung-to-invest-11-biilion-into-qd-displays/
6 https://doi.org/10.14279/depositonce-7107
7 https://doi.org/10.1021/jacs.8b12908
8 https://doi.org/10.1002/sdtp.13114
9 https://doi.org/10.1016/j.orgel.2013.11.003
10 https://doi.org/10.1080/15980316.2019.1614487