QD Vision Response to Nanoco-Dow Submission

QD Vision respectfully requests the opportunity to respond to the recent submission by Nanoco and Dow Electronic Materials ("Dow") (together "Nanoco/Dow") in opposition to our pending December 21, 2012, Request for a Renewal of Exemption 39 under Directive 2011/65/EU (RoHS II), for Cadmium in II-VI LED Downconversion designated as ROHS No. 2013-2. Time precludes us in responding in full to the various points raised in the Nanoco/Dow submission. Although the public consultation period on our request has been open for 3 months, Nanoco/Dow did not post their submission until less than two business days prior to the consultation's closing date. Hence, QD Vision was not afforded a realistic opportunity to respond comprehensively to the Nanoco/Dow opposition to our pending request to renew our exemption. In this document, nonetheless, we address briefly the key points, inconsistencies and downright errors and omissions in the Nanoco/Dow paper. Because the timing of the Nanoco/Dow submission did not permit us a full rebuttal, we intend to respond more fully to the Nanoco/Dow opposition during the stakeholder meeting on December 13, 2013.

INTRODUCTION

QD Vision, an award-winning nanomaterials company based in Lexington, Massachusetts, delivers advanced lighting and display products that currently are marketed for a variety of consumer uses, as well as industrial applications, worldwide. These products employ the special properties of quantum dots (QD), a new class of nanomaterials. The narrowband, tunable, stable, efficient, and environmentally beneficial properties characteristic of the QDs/II-VI downconversion materials are unique, and -- contrary to what Nanoco/Dow asserts -- there exists no viable, market-ready substitute for them.

Through the renewal of the previously-granted exemption, QD Vision seeks to continue to bring the same superior consumer products -- among them, televisions, monitors, tablets, and cellphones -- to the European market. The small amounts of cadmium in the downconversion material have necessitated this exemption, but, as discussed in our request for renewal, the net gains in the areas of environment, energy, and efficiency all argue quite compellingly in favor of extending the exemption. Enabling the continued use of QD technology also will reduce Europe's reliance on several EC-recognized critical materials. Among the latter is indium, which is associated with the products that Nanoco is attempting to develop and bring to market. Nanoco's interests as a prospective competitor are self-evident throughout the Nanoco/Dow submission and even from its timing.

For the reasons set out below, the Nanoco/Dow arguments in opposition to our pending request are unpersuasive in light of the RoHS Directive, and largely false by either omission or

incomplete understanding of the relevant facts. While our application must be evaluated on its merits, the commercial context in which Nanoco/Dow have filed their opposition is impossible to ignore. Simply put, Nanoco's business strategy for some time has been to put their eggs in the basket of cadmium-free quantum dots (CFQD)s, but in this last quarter of 2013 Nanoco and its business partner Dow find themselves with product that is neither market-ready nor, even were they in the marketplace, would they represent a viable alternative to cadmium-bearing quantum dots -- those found in QD Vision's products. Finding themselves approaching a commercial crisis and in the financial jeopardy that often accompanies operations in crisis mode, Nanoco, not surprisingly, is attempting to throw bogus objections into the forward pathway of a successful competitor.[1]

The impetus for the Nanoco/Dow submission is telling because the submission is flawed in so many respects. But regardless of whether the submission is viewed as an effort to promote sound science and informed regulatory policy or as a last-gasp attempt to cast aspersions on a competing product, the relevant point is whether Nanoco/Dow's allegations are correct, which they are not. The most important points touched on by these allegations, and the reasons why they are devoid of merit, are summarized below.

REBUTTAL TO SPECIFIC NANOCO/DOW ASSERTIONS:

1) Regarding OLEDs: *"Energy usage is currently higher than for LCD TVs but likely to reduce dramatically over coming years."* – In fact, OLEDs have been on the market since 2001, recording $91M in display revenue in 2002, a level that is probably similar to that of QD component revenue in 2013. Given OLED's 11 year head start on the display market, it makes sense to conclude that QD efficiencies are likely to improve at a much faster pace than OLEDs in the coming few years. For OLED revenue data, see, for example Allen, Kimberly, Ph.D. "OLED Marches On: Critical Paths for an Emerging Technology", iSupply Webinar Series, 2003.

[1] Nanoco, the sole pure-play quantum dot company whose shares are publicly traded, has for some time adopted a business strategy focused solely on CFQDs. Nanoco's product still is not complete and, as noted, is far from ready to be launched in the market. Thus a worrisome scenario faces Nanoco -- a publicly-traded company without a viable product and without sufficient cash reserves to continue operations past 2014. Nanoco recently disclosed that it has been forced to turn to public markets in an effort to raise capital. Against this backdrop, Nanoco is confronted with the reality of QD Vision and 3M, competitors actively participating in the marketplace with several well-received cadmium-containing products -- from tablets to televisions. In Nanoco's struggles to achieve a market-ready product, it is not surprising to see an unfolding strategy that includes pursuit of a regulatory ban on competing products.

2) *"However, we understand that energy savings are associated with improved efficiency of the LED backlights and not the down-converting material; LEDs are more efficient than previously used backlight sources, e.g. fluorescent tubes."* – This statement incorrectly characterizes the basic factors that underlie product efficiency for these technologies. All comparisons made for QD Vision's (and 3M's) products use LED backlit displays as the baseline (Figure 10 of the 3M dossier does this the best). The improved efficiency (in the market) of the product is due to the downconverting material (*i.e.,* the QDs) itself, where the combination of quantum efficiency and narrowband emission of the QDs directly improves the efficiency at any given color gamut when compared to the alternative technologies (be they phosphor, RGB LEDs, or CFQDs).

3) *"The proposed new wording is ambiguous."* – Both 3M ad QD Vision have proposed new potential wording for an exemption covering cadmium-containing QDs that is more specific than that in the original Exemption 39. Both the QD Vision and 3M dossiers already make the logical, documented, and science-based arguments that the cadmium contained in QDs yields a net reduction in the amounts in the environment, even in the remote configurations employed.

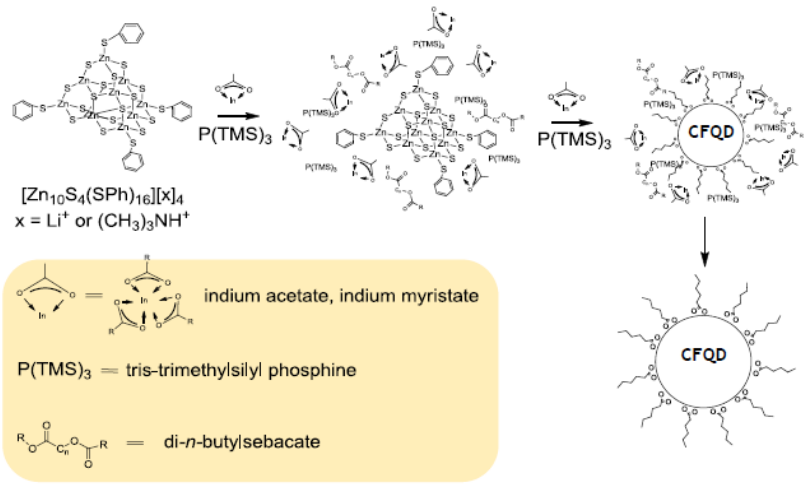
4) *"Since cadmium in Electrical and Electronic Equipment is controlled 10-fold more than the other 'RoHS' substances, its impact cannot be considered small."* – Cadmium is one of the most regulated substances in Europe, and the percentage cadmium by weight is set following from a directive that has nothing to do with RoHS. The directive itself states nothing more or less than that cadmium applications should be used only if there is no alternative. This is precisely the case here. In any event, the use of cadmium inside a television screen is completely safe, and information from recyclers establishes that it can be perfectly recycled using current systems. As all electronic waste must be collected under WEEE, moreover, there is no additional incremental risk in any case.

5) *"Firstly, the energy mix in Europe is different from the USA and the data presented may not be applicable."* – The benefits related to the energy saving are estimated taking into account the energy mix in the EU and according to the EU market observatory for energy, 26% of the electricity is generated by coal. The associated economic benefits have been calculated taking the social cost of carbon into account and this is an important measure to evaluate in economic terms the benefits of avoided CO_2 emissions. We have adopted an extremely prudential approach in our estimates and have performed the uncertainty analysis to take into account all possible elements of uncertainty. The claim by Nanoco is, therefore, uninformed at best and misleading at worst.

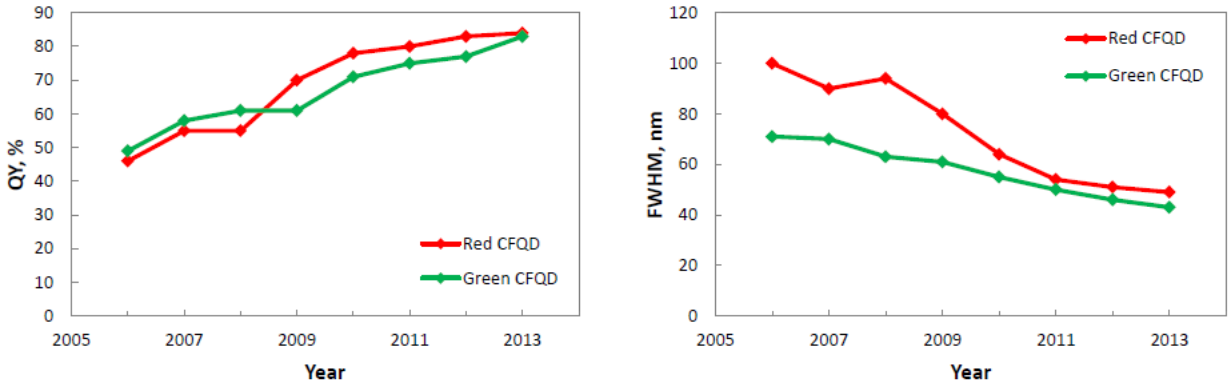
6) In general, the Nanoco/Dow remarks about the socio-economic aspects of QD Vision's application are extremely superficial and fail to take into account a proper cost benefit analysis. The incremental amount of cadmium safely contained in a matrix brought

onto the market through QD Vision's technology is incredible small. Using the European standard risk monetization models, the health cost can be shown to be zero, whereas the cost of carbon associated with higher energy consumption runs into the billions during the likely period that the exemption would run. The facile dismissal by Nanoco/Dow of these benefits to promote their own product, technology, and mercantile interests are completely at odds with the requirements of the RoHS directive to examine the total cost/benefit picture when evaluating alternatives.

7) Nanoco/Dow's arguments in section 2a as to the Indium Phosphide content of Nanoco's products are clearly misleading and serve no purpose but to confuse. While Nanoco's CFQD may not be comprised purely of InP, that is by all public reports the dominant species in the QD core. By the same token, QD Vision could state that technically "QDV QDs are not cadmium," for indeed they are a blend of CdSeZnS, but we do not make such dubious claims. We cite as one example Nigel Pickett's public presentation at IHS E&M Seminar, October 2013 (picture below), where he depicts the effects of the sole addition of indium and phosphorous precursors to a reaction vessel that contains molecular seeds of zinc and sulfur, as follows:



Given this misdirection, Nanoco/Dow then contend that the FWHM of CFQDs therefore will be comparable to that of cadmium-containing QDs. Again, from their own presentation in October 2013:



CFQD™ QY and FWHM data

Here we can see that while the EQE remains below 90% (QDV materials in production and product routinely achieve >90% EQE -- this is why the displays are so efficient), the FWHM quite clearly fails to reach below 40nm FWHM, again in clear contrast to QD Vision's cadmium QDs, which are in the 30-35nm FWHM range in mass production product. (As levels <20nm have been achieved in our laboratories, this gap is only likely to increase, rather than decrease, with time.)

8) On pages 9-10 of the Nanoco/Dow submission, in the section on "on-chip" and, separately, the section on "on surface" it is impossible to ignore that the efficiency of the devices involved is not quoted. Indeed, if a product required only color gamut without regard to efficiency, then conventional white LED technology and thicker/denser color filters simply could be used to achieve the same effect (see, for example, figure 11 of the 3M dossier). A complete product picture, as presented by both QD Vision and 3M, appropriately would address both color and efficiency (and cost, as well, although this element has not been deemed as relevant to the RoHS process).

9) On page 11 of the Nanoco/Dow submission, in addressing SSL, the arguments that 60-70 nm red downconversion is optimum is not supported by the relevant research, nor is this position accepted by the industry. QD Vision explored this aspect extensively leading up to the launch of our SSL product in 2010, when it became evident that narrower-band light has a clear, beneficial effect on the color quality vs. efficiency tradeoff. Indeed, Nanoco/Dow's own Table 4 demonstrates that when efficiency and color quality are depicted together, the broader-band CFQDs impart no value to the SSL products in which they are evaluated. Insofar as the 5000K column seems to make the point that by using broader band CFQDs, one can maintain CCT, decrease CRI, while also decreasing energy efficiency, this is one point on which QD Vision and Nanoco/Dow can agree. But it is not a point that supports Nanoco/Dow's position.

AVAILABILITY OF ALTERNATIVES

The RoHS directive clearly sets out the requirements for the adaptation to scientific progress in article 5. The following section, in particular, is relevant with regard to the suggestion that Nanoco's technology is a viable alternative:

"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,

— the reliability of substitutes is not ensured,

— the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof"

Nanoco's submission fails on all these points. Most critically, so long as the Nanoco products are not in the market, they do not represent a viable alternative to cadmium bearing QDs. Nor do they represent a completed product whose performance, specs, and the pluses and minuses that are inevitable in any product, can be measured and quantified. QD Vision's products are in Sony TVs, while 3M products are in Amazon Kindle HDX tablets. Nanoco's products, by contrast, have not left the laboratory.

- The reliability of Nanoco's alleged substitute is far from assured, as the technology is not yet even fully operational, as Nanoco itself acknowledges. Further, the technology has not yet been scaled into production or indeed tested in anything but a laboratory setting.[2] It is a commercial reality that there is zero chance that the market would embrace Nanoco's technology even if it appeared to perform on par with QD Vision's products (which it clearly currently does not) until they can rigorously prove system level performance in color, efficiency, cost, and quality that meet or exceed that of what is already in the market.

[2] While Dow has committed to scaling up the manufacture of CFQDs, this is but one early step in the process of launching a consumer electronic device that contains the material. From QD Vision's experience, that process is likely to take several more years, if the product reaches the market at all. Nanoco's own annual report to investors from 2009 (at page 13) states that "Nanoco is working with a number of global companies involved in the LCD TV market and the first TVs to include Nanoco quantum dots could be on the market as early as end 2011, early 2012." Some four years later, it is obvious that Nanoco's estimates of time to market were far too aggressive.

- At no point has Nanoco made any effort to show that the total balance of environmental benefits is in favour of its technology. The extraction and refining of Indium is known to be a highly polluting process, whereas the cadmium used for QD Vision's products is plentiful (due, at least in part, to the phasing out of nickel-cadmium batteries) and extraction is much simpler. Nanoco/Dow, furthermore, fail to take into account the added actual costs of carbon related to higher emissions, let alone the added cost of extraction. When a submission addresses the possible benefits of a technology into account but disregards both the associated challenges and costs, this raises a red flag. While a benefits-only "analysis" obviously will cast in a rosy light a purported alternative to the use of a RoHS substance, such an approach is definitively not what the directive contemplates.

In sum, the nascent-at-best Nanoco technology advocated in the Nanoco/Dow submission cannot be considered as a realistic alternative to the proven QD Vision technology for purposes of the RoHS directive, as it applies to QD Vision's pending application. At best, and in the most optimistic light, the Nanoco/Dow submission shows that in the future there may exist another technology that could be competitive with the QD Vision technology (as both the QD Vision and 3M submission contemplate at the end of the decade). This is manifestly not the viable alternative envisioned by the RoHS directive.