Questions

1) Annex III of the RoHS Directive was reviewed in 2008/2009. It was assessed that at that time high melting point (HMP) solders were used in the following applications[1]:

   I. Internal electrical interconnections within an electronic component

   II. Die attach

   III. Plastic overmoulding

   IV. Ceramic BGAs

   V. High power applications

   VI. Solders for mounting electronic components onto sub-assembled modules or sub-circuit boards

   VII. Solders used as a hermetic sealing material between a ceramic package or plug and a metal case

   VIII. Others (please specify)

   Please classify your application for which you request the continued use of lead HMP solders in the above scheme.
   Application is category V (as top category) with subcategories I, II, VI. As electronic component category we understand devices according to Intern. Standards IEC60747-15, -2, -6, -8, -9 (previews attached).

2) You request the use of LHMP in in power semiconductor devices. How do you demarcate power from other semiconductor devices? If possible, please give quantitative criteria like voltage, current, other criteria, or combinations thereof.
   Generally power devices incorporate means to dissipate thermal losses (during on-state, control, switching & off-state) to the environment, e. g. surfaces to be in close contact to heat sinks etc. Typical examples of cases are detailed in standards JEDEC SOT-227, TO-247 or TO-220. As an alternative rough definition for power devices: power devices should be capable to sustain steady state currents of >1 A and/or blocking voltages beyond 200 V with no upper limit to date.

3) You use the term “high reliability semiconductor power devices”.
   a) Are semiconductor power devices the same like power semiconductor devices?
      Yes
   b) What is the difference between high reliability semiconductor to other, “normal” semiconductor power devices?
      High reliability devices should be designed to survive (> 10 a) in life supporting applications (like defillibrators), in windmill generators, in drives for traction (trains, etc.), in telecom (servers etc.) mostly under harsh environmental conditions.

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1 For details see report of (Carl-Otto Gensch, Öko-Institut e. V., et al.), with the assistance of Stéphanie Zangl, Rita Groß, Anna Weber, Öko-Institut e. V., and Otmar Deubzer, Fraunhofer IZM (19 February 2009), page 99 t o106

"Normal" application could be defined as consumer market with short life cycles. See also: http://www.ixys.com/Applications.aspx

4) You state that the use of LHMP is especially important when combining large power dies with copper base plates (headers).
   a) Are lead-free alternatives available for smaller dies, and what would "smaller" mean quantitatively?
   e. g. Au-Si eutectics for die edge sizes < 3 mm.
   b) If the combination of larger power dies with copper plates is a root cause for the use of LHMP: what are alternative base plates that could be used, or otherwise, what are the reasons in case they cannot be used? IXYS Germany (formally BBC, ABB) is a pioneer to offer an alternative based on DCB technology which has been under strong dispute among competitioners in the past (see publications …), now adopted by most competitioners. DCB technology is more costly; however, it includes el. insulation. See especially:
   http://www.ixys.com/SearchResults.aspx?search=ISOPLUS&SearchSubmit=Go
   and for "*vollisolierte Sonderbauformen von TO-220*":
   https://de.wikipedia.org/wiki/Liste_von_Halbleitergeh%C3%A4usen#Plastikgeh.C3.A4use_mit_und_ohne_K.C3.BChlfahne

5) IXYS quantifies the amount of lead entering the EU market due to the requested exemption with around 50 000 kg per year. Please substantiate this figure with a calculation. Assuming no significant increase of turn over in this category of devices; the amount was taken from the initial exemption request.

6) You mention compression bonded contact systems as a lead-free alternative for very high power semiconductor devices with packaging mostly being realized as voluminous ceramic cases.
   a) Please provide more details about this technology including a definition of "very high power". Useful when steady state currents > 500 A, surge currents >= 50 kA, silicon die diameters > 25 mm (so-called "hockey pucks").
   An example providing the range/definition of high power is provided (data sheet) in attachement (housing dimensions page 9) and as well as patents.
   b) Please explain the application fields of this technology and where it is an alternative to LHMP. Typical application: "hockey puck" stacks for HGÜ.
   c) You state that packaging is mostly realized as voluminous ceramic cases. What are alternative packaging technologies? Ceramic being replaced by plastic case but still with compression bond technology, see attached patent DE2825682C2. However, not successful because not reliable due to humidity leakage of plastic housing.

7) You state that electrically isolated package versions in DCB technology with metal bonded alumina or AlN ceramic isolator substrates have a better CTE match and more SAC type solders are used.
   ~~d)~~a) Please spell out the acronym "DCB" **d**irect **c**opper **b**onding, sometimes also named "direct bonded copper (DBC)".

~~e)~~b) Please provide more details about this technology., A technology to combine copper with ceramics like alumina without any interface material (BBC/IXYS patent EP85914).

~~f)~~c) Please explain the application fields of this technology and where it is an alternative to LHMP. Please see http://www.ixys.com/SearchResults.aspx?search=ISOPLUS&SearchSubmit=Go

In this context it should be mentioned, however, that ISOPLUS devices for applications in the SMT (**s**urface **m**ount **t**echnology) need LHMP for internal connections. This is due to the fact that during SMT processing the devices have to survive temperatures exceeding the lead free SAC melting point (see also IEC 60749-20, table 6 and Fig. B.9 as well as IEC61190-1-3, table B.2). Otherwise ~~the~~any internal lead free solder connections in the plastic molded devices would remelt and degrade their quality.

~~7)~~8) In your exemption request IXYS says that many customers still require cheaper non-isolated versions.

a) Do they require the cheaper non-isolated versions because

i. the DCB technology is not a viable alternative for their applications,

ii. or because of the lower price?

In case i~~a)i~~) applies, would a redesign of your customers products allow the use of the DCB technology?

The main reason is the lower price (8a, ii).